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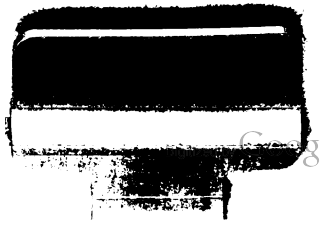

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Agriculture

CACAO.

BY

J. HINCHLEY HART, F.L.S.,

SUPERINTENDENT BOTANICAL DEPARTMENT.

TRINIDAD:

PRINTED AT "THE MIRROR" OFFICE, PORT-OF-SPAIN.

1900.

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"CACAO."

A TREATISE ON THE CULTIVATION AND CURING OF "CACAO."

BY

J. HINCHLEY HART, F.L.S.,

SUPT. BOTANICAL DEPARTMENT, TRINIDAD.

"QUI NON PROFICIT DEFICIT."

(SECOND EDITION).

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PART I.—CULTURE.

CHAP I.—SELECTION OF LAND &c.

ERRATA.

p. 4—For "se ection" *read* selection.
p. 9—For "give" *read* gives and for "exremely" *read* extremely.
p. 12—For "possesses" *read* possess.
p. 13—For "Boca" *read* Bocare.
p. 15—For "increasing" *read* increase.
p. 16—For "cartainly" *read* certainly
p. 22—35th line, insert "*his*" between "*to*" and "*own.*"
p. 32—For "of" *read* or.
p. 45—For "moring" *read* moving.
p. 46—For "rouud" *read* round.
p. 52—For "skimed" *read* skinned.
p. 59—1st para. Insert *the* between "but" and "accuracy."
p. 60—For "coommon" *read* common.
p. 112—Insert *by* after "distinctly" in sixth *para.*

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PART I.—CULTURE.

CHAP. I.—SELECTION OF LAND, &c.
" II.—SELECTION OF SEED—NURSERIES.
" III.—PLANTING AND SHADING.
" IV.—MANURING AND PRUNING.
" V.—ROADS AND DRAINING—TEMPERATURE AND RAINFALL.

PART II.—PREPARATION FOR MARKET.

CHAP. VI.—PICKING AND HARVESTING.
" VII.—FERMENTATION, CURING, &c.
" VIII.—WASHING, DRYING, POLISHING.

PART III.—SCIENTIFIC AND MISCELLANEOUS.

CHAP. IX.—BOTANY AND NOMENCLATURE, DESCRIPTION OF TYPICAL FORMS.
" X.—DISEASES, &c.
" XI.—EXPORT, VALUE OF ESTATES, BUILDINGS, LABOUR.
XII.—THE CHEMISTRY OF CACAO, BY PROF. J. B. HARRISON, M.A.
" XIII.—MANUFACTURE OF CHOCOLATE.
" XIV.—TRANSIT OF SEEDS AND PLANTS.

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TABLE OF CONTENTS.

CHAPTER I

PAGE

SELECTION OF LAND.—Suitable soils—Aspect—Worn out lands—Tidal lands unsuitable—Shelter belts of Timber—Forest growth a guide in selecting land—How to proceed in choosing a property—An ideal spot for Cacao growing—Elevation above sea-level—Mean Annual Temperature—Chemical Analysis of soils 1–3

CHAPTER II.

NURSERIES—Cacao usually raised from seed—Preservation and transit of ripe seeds—Grafting Cacao—Method of transporting—Seeds for Nurseries, how to select for improving varieties—Varieties when established should be given local names—A bad arrangement for a Nursery and a good one—Raising plants in boxes—Coconut refuse—Transplanting—Tap-root—Injury to roots—Trimming wounds—Water supply—Manure not generally required—Leaf mould 4–7

CHAPTER III.

PLANTING AND SHADING.—Preparation of land by Contract—*Quarree* as Spanish measure—Planting from Nursery, and planting at stake—Use of bamboo joints for plants—How to sow seed at stake—Transplanting to field—Treatment of plants before planting—Advice not to plant in wet weather—Distance apart to plant—Grenada planting—Choice of wide or close planting depends on character of soil—Supply of vacancies—Planting by Contract—Crops grown by Contractors—Ordinance to regulate Contracts—Sum paid per tree to Contractor—Disadvantages of Contract work—Dishonest Contractors—Intermediate crops on new land—Shade—Grenada grows without shade—Trinidad uses shade—The reason discussed—Name of shade trees "Bois Immortel"—Shade trees store Nitrogen—Castilloa considered unsuitable for shade—Para rubber—Terminalia or "Myrabolans—Saman tree—Distance to plant shade trees—Smaller or primary shade plants—Value of Banana—Weeding and "cutlassing"—Stem of trees not to be covered by cut-weeds 8–14

CHAPTER IV.

MANURING AND PRUNING.—Description of tree in good health—Such trees do not require manure—Application of manures—Farm yard manure safe to use—Chemical manures sometimes dangerous in their application—Method of application, with surface, and with deep rooting plants—NATURE'S method of applying manure—Culture of trees different to culture of cereal crops—We cannot command NATURE, only assist her—Hints on culture—The application of artificial manure—The use of lime—Plants do not take all their food by the roots—Necessity of maintaining a proper state of health among the leaves—*Pruning*—Its effect—How to perform it—How to balance a tree—Bearing branches sometimes need cutting out—Useless wood to be cut out—Care against making ragged cut—"Gormandizers"—How to make use of them at times—Wounds by saw to be cleaned with knife—All pruning instruments to have a keen edge—Time for pruning—Influence of the moon—Trees should be pruned annually—Pruning makes wounds—All prunings to be burnt—Manual dexterity in use of knife cannot be taught by writing—Maxims for the cultivator 15–23

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Table of Contents.—Continued.

CHAPTER V.

PAGE

ROADS AND DRAINING.—Necessity of roads—How to make them—Economy of having a proper system—General principles only can be laid down—Why drainage is required—Form of drains—Best direction for drains—Natural outlet for drainage waters should be secured—Subsoil drainage practically impossible—Theory good but practice unsound when referring to Trinidad. —*Temperature*—Humidity a most important factor—Value of hygrometrical observations—Continued drought fatal to the Cacao tree—RAINFALL—Countries with same rainfall may not possess same humidity—Comparison with other countries—Planter must depend upon humidity more than rainfall and temperature—Difference of humidity at increased elevation above sea-level 24-28

CHAPTER VI.

PICKING CROP.—Cacao Hook—Instructions for harvesting crop—Importance of cutting ripe pods only—Skilled workmen only to be employed—Different treatment required by different varieties—Separation when shelling or "breaking" of ripe from unripe produce—Rate of wages for picking—SHELLING OR BREAKING.—How breaking is performed—Uphill work of reform in methods practised—Central factories—Pessimists' views—Obtaining a name—Quality depends more upon the special kind grown, than upon soil, cultivation, or preparation 29-32

CHAPTER VII.

FERMENTATION.—Prizes for Essays given by Trinidad Government—The necessity for the operation—The change that is brought about—What causes the change—General results—Cacao analysis—Professor McCarthy's analysis—An experiment in Fermentation and its results—Comparative weight of waste and weight of kernel—Why dissimilar methods produce similar results—"Stewed in their own juice" rather ancient—Practice of Venezuelan planter described by Sir William Robinson—Destruction of vitality—An important principle of Fermentation—Aublet's description of Fermentation dated 1775—Translation—Degree of heat required—Probable action of *diatase*—Skin of bean a protection to the cured product—Average heat required in sweating 33-42

CHAPTER VIII.

WASHING.—Ceylon and West African methods—Advice of London Brokers—Dr. Morris' opinion on the variety grown in Ceylon—Dr. Trimen on same—Change of character apparent—How Cacao is dried in Trinidad—Description of house required—Length of time for drying—Prizes for apparatus for artificial drying—Description of Ceylon drying house—Cacao said to require slow drying—Colouring—Red earth—Venezuelan practice as translated by Sir William Robinson—Description of San Antonio earth—"Dancing"—Mildew —Hand rubbing—Description of a well cured bean—How plump appearance is said to be secured 43-49

CHAPTER IX.

BOTANY AND NOMENCLATURE.—Mexican name—Various species of Cacao—Dr. Morris' classification—Our own classification of varieties—Criollo—Forastero —Calabacillo—Criollo, the finest Cacao—Dr. Trimen's interpretation of the word Criollo—Proper interpretation—Origin of the names—How to improve the quality—Nicaraguan Cacao of the Criollo type—Theobroma pentagona—produces a very fine Commercial Cacao—Epidemic of disease amongst Trinidad Cacao, 1727—Introduction of Forastero—Typical forms of beans with illustrations—Discussion on value of the varieties—Comparative remarks—Trinidad Plantations of a mixed character—Caused by Contract system—Forms of leaf—Reference to cultivation in Jamaica and the word "*blast*" *Theobroma bicolor*—"*Wariba*" "*Wari*" or wild hog—Reference to illustrations of *Theobroma guyanensis, Theobroma sylvestris, Theobroma angustifolia* 50-60

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TABLE OF CONTENTS.—Continued.

CHAPTER X. PAGE.

DISEASES, &c.—Diseases few—Black rot—Canker—Dr. de Verteuil's description of blight—*Phytophthora omnivora*, destroys Cacao pods—Description of attack—Experiment with infected pods—Analysis of Healthy and diseased fruits by Prof. Harrison—Remedial measures—Re-introduction or introduction of a strong variety, 1757—Parasol ant—Cacao beetle—Means of destroying same—Ordinance enabling Governor to declare districts infected—The Asphyxiator—Belt's opinion—Aphides—Wood ants—Vegetable parasites. Loranthus, Dodder—Epiphytes—"Orchids"—Squirrel—"Manicou Gros Yeux" 61-70

CHAPTER XI.

EXPORT, &C.—Export of Cacao—Customs returns—Value—Price of Crown Lands—Estates on the market—Best course for investors—Yield, the best test of value of Estates—Dr. Morris on the bearing of trees—Yield per tree—Yield and value per acre—Working expenses—Buildings required—Proprietor should be resident—Cost of curing-houses, store-rooms and offices—Cost of labour—Skilled *vs.* unskilled 71-76

CHAPTER XII.

THE AGRICULTURAL CHEMISTRY OF CACAO.—Contributed by Prof. Harrison—Analyses trunk, branches, leaves, of Cacao tree—Proportions of nutriment required—A good Cacao soil—Analyses of Cacao soils—Harrison—Analyses of Cacao soils—Carmody—Analyses of the composition of the Cacao pod, bean, husk, pulp, &c.—Deductions from analyses—General results of examination 77-107

CHAPTER XIII.

FOOD VALUE OF CACAO, MANUFACTURE, &C.—Chemical composition of the bean by P. L. Simmonds—Table of comparative analyses—Results not flattering to chemical science—Active principle of the bean according to Professor Church—Forms of preparation—Discussion on the nutritive value of Cacao—Method of manufacture—Adulteration—Roasting—Grinding—Making up,—"Food for the Gods"—Way to make a real cup of Chocolate—Cacao butter—Essential oil—Cacao powder—Adulteration experiment with different kinds—Visit of the author to Cadbury and Rowntree—Sugar sold at £336 per ton by Cacao manufacturers—The word "CACAO" 106-115

CHAPTER XIV.

TRANSPORT OF SEED AND LIVING PLANTS.—Method of packing seeds and plants—Growing on the way—Wardian cases—Sowing seeds in cases—Conclusion 116-117

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PREFACE.

In May, 1882, the writer's attention was specially attracted to the subject of the cultivation of Cacao, by being called upon while in the Jamaica Service, by Mr. Morris (now Dr. Morris, C.M.G., &c., &c.), then Director of Public Gardens Plantations, Jamaica, later, Assistant Director of Royal Gardens, Kew, and now, Imperial Commissioner of Agriculture for the West Indies, to assist him by the preparation of drawings and diagrams and models of his Lecture on the cultivation and curing of Cacao, delivered under the auspices of the Jamaica Institute.

Dr. Morris previous to his lecture had paid an official visit to Trinidad for the purpose of obtaining information relative to the production of Cacao. The lecture was published in pamphlet form and obtained a wide circulation, and has since been republished. The majority of *facts*, gathered in Trinidad by Dr. Morris, were collated with his usual ability, and most of them have stood the test of publicity, without encountering serious contradiction.

Being frequently applied to for information on the same subject, I was induced to undertake the first edition of this work for the purpose of satisfying such enquiries, and that being exhausted, I have now the honour of presenting to the Public a second issue. Over eleven years' service under the Jamaica Government, during the latter part of which I administered the Botanical Department of that Island, and over thirteen years in my present office, a total of over twenty-five years West Indian service, all spent in Botanical work, will I hope fairly entitle me to be heard on the subject. It is one to which I have devoted close attention, and I am confident that full credit will be given for the endeavonr to put into suitable and handy form, information suitable to the beginner, suggestions acceptable to the experienced, and matter of some interest to the general reader. The prize essays on Fermentation printed as an appendix to the first Edition have been omitted in the present issue for various reasons, but the subject matter is dealt with in Chap. vii. to which the reader is respectfully referred.

J. H. HART, F.L.S.

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CHAPTER I.

Selection of Land.

OR the cultivation of the Cacao tree the soil selected should be one which possesses the requisite depth of surface soil, and one moderately rich. A shallow soil resting upon hard bed rock is totally unsuitable, while a moderately shallow soil resting upon a friable rock bed is often found to grow Cacao to perfection. It is generally considered among Trinidad planters that a loose clay or clay with an admixture of a fair proportion of sand and lime is favourable to the growth of Cacao. If the soil is covered with a vegetable deposit which has accumulated from the falling leaves and branches of the original Forest, so much the better. If land can be found on the banks of a stream or river where there is considerable depth of alluvial deposit, such a position, if capable of being well drained, is a sure source of wealth to the Cacao planter. Hard, dry, rocky soils, stiff clays, mountain sides, where great detrition frequently takes place, shallow sands, and boggy ground should be carefully avoided. The aspect of the land should always be carefully considered. A site exposed to trade or prevailing winds, or to strong sea breezes, should not on any account be chosen for a Cacao plantation.

Land which has been previously cultivated with other crops may be chosen when it has good depth, is easily drained, and is capable of being improved by the application of suitable manures.

Worn out Sugar lands are dangerous investments for the intending Cacao planter as a rule, but an intelligent choice even here, by men who are acquainted with the local character of the soil and the Cacao tree and its requirements, will often result in the development of a productive plantation.

Salt is inimical to the growth of the Cacao tree, and lands liable to be inundated with tidal waters should never be purchased.

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Shelter belts of timber should be left on the windward side of a plantation when it is being made from the original Forest, and on established Estates it would be found economical and convenient to *cultivate* to windward such Timber trees as will form good "wind breaks" while at the same time, they will grow into and afford ample material for erection and repairs of suitable buildings for residences, and for the purpose of curing and storing of the crop.

In Nicaragua the Mango tree is planted for shelter though of little use for timber. The seeds are sown a foot or fifteen inches apart, in straight trenches on the windy sides of the plantations. The trees are allowed to grow close together and are kept trimmed, hedge fashion, on either side, but allowed to grow to their full height. Thus grown they form the most efficient wind-break I have seen used.

A careful study of the trees growing upon Forest lands will afford the intending planter a fair guide as to what the land will produce. A soil producing nothing but scrubby original growth can hardly be expected to produce good Cacao, and in fact never does. Sometimes however, land covered with heavy Timber is found quite unsuitable for cacao cultivation, but this is the exception rather than the rule, and much must indeed depend upon the planter's own faculty for observing surrounding conditions, whether a successful choice will eventually be made.

A planter strange to the country in which he proposes to settle, should never choose a site, or buy properties, until he has resided in the land for a sufficient length of time to enable him to be capable of forming a correct judgment from his own special observation, as well as from the reports of other persons.

An ideal spot on which to found a Cacao plantation is, a well sheltered vale, covered with large trees, protected by mountain spurs from the prevailing winds, well watered, and yet well drained, with a good depth of alluvial soil on which rests a thick deposit of decayed vegetable matter, easy of access, and in a district distant from lagoons or marshes for the sake of the proprietor's health. Such a spot in a climate similar to that of Trinidad could not fail to produce regular crops of the finest quality of Cacao.

Elevation above sea-level has also to be considered in choosing ground for planting Cacao. The higher the elevation the lower the degree of temperature experienced, and the trees make smaller growth and give less in annual produce.

Plantations existing at over a thousand feet above sea-level in Trinidad are few and far between, and cannot take rank among first-class estates.

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The mean annual temperature in Trinidad at sea-level is 78.47 Fah. taking a twelve years average. From this the reader may conclude that planting Cacao at higher elevations is not a measure of economy or good practice, unless in specially favoured positions with regard to soil and exposure.

It would be a grave error to assume that land fit for the cultivation of Cacao can be chosen by the results of chemical analysis alone, for it is quite possible for land to contain all the substances required for the growth of a particular plant, and yet be totally unsuited to grow that plant, owing to the materials being present in a form which cannot be taken up by the roots.

Sometimes the mechanical nature of the soil is quite as important as its chemical constituents, and unless a mechanical as well as a chemical analysis is made, its suitability for the purpose cannot readily be ascertained. Although these drawbacks exist, yet Chemical analysis is very useful, in fact essential in securing a right judgment on the suitability of land for any particular crop, but taken alone it should not be trusted. Whenever used, samples should be taken with the greatest care from those parts of the land which would give a fair average of the area under examination. Unless this is done, chemical analysis is not alone useless, but becomes positively misleading. For instance, a planter takes a sample of soil from his field, and brings it for analysis; the chemist tells him it is good land, rich in various constituents and excellent for the crop he proposes to plant. In faith of this the planter buys and plants, alas! with failure—Why?—the sample was taken from a spot which contained or received the wash of the surrounding land, and was in consequence as rich in proportion, as the adjoining ground was poor and valueless. Chemical analysis is a valuable adjunct to practical planting experience, but without that experience leads the planter into frequent dilemmas. *In Johnston's elements of Agricultural Chemistry p. 147, 17th Edition the Editor warns Students that this is so, in the following words:* "Chemical analysis of a soil as ordinarily conducted, valuable though it is in some respects, is not of much service in indicating the actual fertilizing matters at the moment available in the soil. The agencies at work whereby the elements of fertility are rendered available for the plants' uses, are so complicated and numerous that *the best test of a soil's fertility* is to carry out experiments with the plant itself."

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CHAPTER II.

Selection of Seed—Nurseries.

CACAO has hitherto been invariably raised from seed by the planter. The seed possesses but a short life, if exposed to dry air: if kept in a moist situation, fermentation quickly sets in and it becomes useless. It is thus very difficult to transport Cacao seed to distant countries, or to keep it for any length of time, unless placed under conditions favourable to germination. Cacao may be sent in ripe pods for short journeys not exceeding 12 or 11 days, if the pods are kept entire and without bruises, and well packed. A good method of transporting seeds to a distance is to plant them in Wardian cases and allow them to germinate on the voyage.

For nursery purposes seed of the best quality should be used, the largest beans should be selected, and care taken to procure them from well ripened pods. It is a great mistake to use seed of inferior varieties or that taken from half ripe pods and from trees in indifferent health. This applies to all varieties.

Some trees are better bearers than others, some produce finer pods, and the choice, for seed purposes, should rest upon those which produce *fine large pods, good beans, and bear regular crops.* In the vegetable kingdom as a rule, like produces like; yet it is well known that variations do occur, and it is certain that the chances of procuring a good class of plants from seed are in favour of the course recommended, rather than by procuring seeds from the refuse pods of a plantation and expect good results to follow.

Seed should also be taken from trees situated at a distance from inferior varieties, for the purpose of avoiding as far as possible the variation which will naturally occur, where cross fertilization is free to take place, for if poor varieties are near to the seed trees, the latter will most certainly produce a variety having some of the characters of the poorer kinds blended with its own.

Too much attention cannot be paid to the selection of a proper quality of seed, if it is the planter's aim to improve the quality and quantity of his productions.

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This point was forcibly urged in De Verteuil's "Trinidad," 1884, p. 223.

During the year 1898 the author proved by experiment that the Cacao tree really admitted of propagation by grafting. The method used was that of "inarching" or grafting by approach. Having found trees possessing first-class qualities, it is very easy to see that these may be reproduced in quantities sufficient for large areas, and that fields of Cacao may be planted with exactly the same kind of tree as a selected parent, and that such areas would give produce "regular," in quantity and quality, year by year. There can be little doubt therefore that the practice of using grafted trees, instead of the unreliable seedling, will be of the greatest benefit to the planter.

When planting from seed, it is well known that the produce varies, and no two trees can be depended upon to give pods of the same size, or beans of the same quality. When selecting pods for seed, it is at once clear, that if taken from the open field, only the maternal parent of the seeds contained therein, can be known; while the interminable varieties which everywhere exist clearly prove that cross fertilization readily takes place. Variation is also to be well seen in the cured produce, for although the beans may have a common or family likeness, all dealers know, that if cut through and carefully examined, there are material points of distinction, and few can be found exactly alike.

The difference that an "even sample" would make to the seller, is therefore obvious. Once a tree has been selected and largely propagated, owing to the possession of superlative qualities, it is evident that the produce must be of an even character, and that taken year by year, the crop will vary but very little in general quality. By using the process of grafting, the planter will be able to secure trees of one habit, pods of one colour, and beans of the very best quality. Such beans when cured, would be unique in "break" and general condition; and would be immensely superior to any produce harvested from seedling trees. To adopt grafting as a regular practice upon a Cacao estate would only be to adopt a method of fruit culture so long and so successfully followed in Europe and America. Why should there not be, Fowler's "Nonpareil" Cacao, Agostini's "Bright-red," Walker's "Excelsior" and Needham's "Criollo;" as well as Parkin's "Surprise" Potato, Master's "Jargonel" Pear, or Bates' "Marmaduke" Cherry, is not easy to define; and it is probable the adoption of the art of grafting will bring such kinds upon the local market, to its evident advantage.

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Having secured good seed, the planter has to decide upon his nursery, and the methods he will employ for the purpose of raising sufficient stock, to plant out the ground he has prepared. Every planter has his own views, as to the best method of raising seeds and the position most suitable for nurseries. What I should consider a bad method would be; a nursery made in stiff clay soil permeated by the roots of surrounding trees and covered by their heavy shade, seeds sown thickly without removing pulp, some deep, others on the surface, beds sometimes allowed to get dust dry, at other times deluged with water. Such, cannot be expected to produce healthy plants. On the contrary, Nurseries made in a friable soil, well pulverized, in an open situation, the seeds well cleaned and sown regularly their own diameter beneath the surface of the soil, carefully watered when required, artificially shaded from the direct rays of the sun, protected from the trampling of animals, the ravages of rats and mice, and carefully weeded, when required; may reasonably be expected to produce strong and healthy plants. With those who prefer raising plants in boxes—a very handy and economical method all things considered—the best method to employ would be to procure well rotted and sifted Coco-nut refuse and to sow the seeds regularly, about $\frac{3}{4}$ inch below the surface, the boxes being made about six inches in depth and well drained. If Coco-nut refuse is not to hand, a suitable substitute may be found in well decomposed leaf mould. Immediately the plants have developed their first pair of leaves, they may be potted or transferred to nursery beds—in both cases, shading them until well established. If transferred to beds, the plants should be put out, about twelve inches apart each way—*taking especial care not to place the plant too low in the ground.* More plants die from this cause than from any other, both in nursery and in the field. No plant whatever, whether Cacao or any other, should ever be placed in the ground lower than the position in which it stood in the soil as a seedling. Many people tell us a great deal about "tap-root." Personally I have no reverence whatever for even the name of "tap-root" but at the same time I have every respect for the principle which has led to the great respect paid to the "tap-root," by the greater number of West Indian planters; and this principle is, that even the slightest damage cannot occur to *any* root without loss to the plant with which it is connected.

Every care should therefore be taken not to injure roots, and in making nurseries, it is best to use a friable soil, for the plants can always be removed from this without the injury they are sure to sustain when grown in heavy soil, as it shakes off the roots readily and leaves them uninjured when ready for planting.

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In case, however, of injury to the roots in transplanting, a jagged wound should always be trimmed with a sharp knife, and a broken or wounded root should never be allowed to remain but should be at once cut off with a sharp knife, as it is very liable to induce disease and spread decay—either when planting in nursery or field.

Transplanting may be resorted to as a check to growth, at times when nursery plants are becoming somewhat overgrown and no ground is ready in the field. If carefully performed, this operation will render the plants hardy and better able to stand transport to a permanent position.

Nurseries should always be placed near water, and well protected from wind, and direct sun; but they are always the better for having plenty of light.

Manure is not required in the nursery, unless the ground is very poor, and it should on no account be used in the seed bed. If the ground needs it, it may be slightly enriched with well decayed leaf mould in suitable quantities, but it should be the planter's earnest endeavour not to induce rampant growth in the nursery, as the plants produced under such conditions are sure to suffer when finally put out in the field. A healthy sturdy plant is much better than a large and soft wooded one, and will always make a finer tree.

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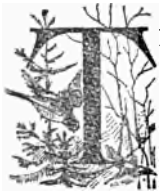
CHAPTER III.

Planting and Shading.



HE preparation of the land for planting is an important and heavy work, especially if the ground is covered with original Forest. In Trinidad the Forest is usually cut by contract at so much per "quarrée," a Spanish measure of 3 1-5th acres. The wood is burned, and the field cleaned, lined, and staked for planting.

There are two methods of planting, which are followed by planters according to circumstances. The first is to raise plants from seeds placed at once in the position the trees are to permanently occupy—commonly called planting "at stake," and the second is to plant out the ground by using plants raised in the nursery until they are from 12 to 24 inches in height. Generally, I believe the opinion of our planters is in favour of using nursery plants, but there is much to be said in favour of planting "at stake." Planting "at stake" means that the plant once fairly started, never has its roots injured in any way by the operation of transplanting and the roots must therefore at once and for all, assume their natural position. In using nursery plants, or plants grown in bamboo joints, the roots must of necessity get somewhat mutilated and sometimes curled or twisted, although the endeavour of every planter should be to raise each plant with a ball of earth adhering, and to see that the roots are preserved as intact as possible.

In using either method of planting, the ground should be well broken up around the exact spot where the planting is to be done. When seed is used, three selected seeds should be placed in a triangle about 6 inches apart and covered with about an inch of soil, pressing the earth somewhat firmly down with the hand or foot, thus ensuring a more regular amount of moisture around the seed than if the earth was left loose. In transplanting plants from nurseries to the field the greatest care should be taken to keep the roots as free from injury as possible, and to secure balls of earth to each plant. The roots must not in any case be allowed to become dry, and to secure a good

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supply of moisture in the plant itself, nurseries should always be copiously watered the evening before the plants are to be removed to the field. In no case should the plants be exposed to a current of dry air or to direct sunshine.

In putting the plant into the ground the planter should make sure that he does not plant it too deep or too shallow,—what is meant by this is described in a previous Chapter. The surrounding soil at the time of planting should be pressed firmly down, but not made hard, allowance being made for dry and wet weather, but plants should never be put in the ground, if it can be possibly avoided, when the ground is in an exremely sodden condition.

It is impossible however to instruct in full by writing how a plant should be placed or planted, and one practical demonstration is worth ten pages of manuscript or letterpress. The novice should therefore seek from the practical experience of others, the requisite knowledge for the purpose.

The distance which Cacao trees should be planted apart will be determined by the planter in accordance with the character of the soil and the elevation above sea-level. The higher above sea-level and the poorer the soil the closer the trees may be planted and *vice versâ*—a distance ranging from 12 to 15 feet apart each way will probably meet all requirements (*i.e.*) 12 feet in poor soil and 15 feet in rich soil.

In Grenada the practice of close planting is followed much more generally than in Trinidad, but successful planters are to be found among those who follow each system. The wide planting cultivator "get more fruit per tree and of better quality than the close planting cultivator;" while the latter is said to get as much from two trees as the former does from one, and as good in quality. Probably more depends upon the judgment of the individual planter with regard to the character of the soil he is working, than upon anything else. If it is poor he will plant close, if rich and deep, he will regulate his planting accordingly. It is not to be doubted however, that where practicable, wide planting give the advantage of affording easier access to the cultivator for the various operations of pruning, harvesting, manuring, weeding, &c., and the plantations where the practice is carried out certainly assume a much better appearaace than those which are crowded with trees. The supplying of vacancies should be carried on during suitable weather, the aim being to obtain a field showing trees of regular size throughout.

Planting by contract has its advantages and disadvantages. It is—provided you have a good contractor—one of the simplest

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and certainly the cheapest and easiest method of establishing a Cacao estate. The system may be briefly described as follows:—

The peasant enters into a contract to plant the land with Cacao trees, and receives for his labour, the use of the land for the purpose of growing annual crops of provisions, *plus* a fixed price per tree, to be paid him at the end of five or six years when the Cacao trees commence to bear, and the land becomes useless for gardening purposes. For many years, and to the present day, this system has been generally adopted in Trinidad. In 1889 an Ordinance or Law was passed controlling such contracts, and now, each contract has to be signed before the Magistrate of the district, and its general provisions have proved very effective.

The sum to be paid per tree, varies in accordance with the situation, and the supply of labour; but generally ranges from 15 cents to 25 cents per tree, or even a little more.

One of the greatest disadvantages of planting by the contract system, is the certainty of having no great care exercised in selecting the seed for producing plants. The peasant's interest is to get the trees to grow, and he knows well that the inferior varieties are hardier than those which produce the finest Cacao, consequently there is great temptation for him to use the seed of inferior varieties for planting.

This of course may be obviated by the planter supplying the seed, or the plants, but even then, it is not always possible or convenient to properly supervise the planting operations, so that the chances are that after all, inferior varieties will be planted.

On the other hand, a proprietor cannot possibly plant as cheaply as a contractor, as the latter is better able to dispose of the ground provisions in the local market, and thus pay himself for his labour. Notwithstanding this fact, there are not a few proprietors who prefer to plant by "day-labour" rather than encourage the contractor to follow a squatting existence for some years upon land, which he is often found unwilling to leave at the termination of his contract. With a dishonest contractor a proprietor often loses one or two seasons; as, it is frequently found that men will take land, grow one or two catch crops, and instead of planting Cacao, disappear!! As contractors are for the most part drawn from the labouring classes, the proprietor has no remedy, for in the attempt to recover, he is simply sustaining further loss without the slightest possibility of obtaining the value of the crops taken from the land.

Cacao is certainly benefited by intermediate cultivation between the row of trees in their younger stages, provided the

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cultivator does not go near enough to the Cacao tree to injure its roots, and planters who reside upon their fields—as all should do who are earnest for success—should endeavour to plant crops of which he can readily dispose, and those which are least exhausting to the land.

SHADE.

The question of shade is one upon which much has been written, and upon which there exists great divergence of opinion. In the Island of Grenada the general practice is to grow Cacao without shade. In Trinidad the prevailing practice is to give the plants permanent shade by planting umbrageous trees at regular intervals through the plantations. Each system has its advantages and its disadvantages, and no hard and fast rule can be laid down, but the novice would certainly be safe in following the general practice of the district in which his land is situated, giving due force to any surrounding circumstances which may justify him in using a modification of the prevailing practice. As stated in a previous chapter, the greatest care should be taken in securing "windbreaks" on the side of the plantation exposed to the prevailing winds, and belts of original Forest should be left for this purpose if practicable, and if this is impossible artificial protection should be secured by planting quick growing trees for present, and forest trees for permanent protection. In Nicaragua, shade is grown sometimes for two years before the Cacao is planted, the hedges of Mango alluded to in a previous chapter being planted at the same time. Here also the shade trees are planted in the same rows with the Cacao. These rows are placed some fifteen feet apart, but the Cacao trees are placed close together in the rows, sometimes not more than six or seven feet apart. This allows a better chance for tillage between the rows and certainly improves the appearance of the field, and I did not observe that the crop was less in consequence.

In Grenada the land in Cacao is sometimes undulating, but in the major part of the Cacao districts it is distinctly hilly. Where the aspect of the plantation affords by the conformation of the ground itself, shade or shelter from a particular direction, artificial shade can certainly be dispensed with in a great measure, but on level land in Trinidad the general practice goes to prove that it is absolutely necessary, to produce Cacao to perfection.

For shade in the lower lying lands of Trinidad the tree generally used is the "Bocare," or *Erythrina velutina*, which affords a deep shade. For the higher lands the "Anauca," or *Erythrina umbrosa* is used. Both are known, together with

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several other, *Erythrinas*, as "Bois Immortel." The Bois Immortel proper, however, is the "Anauca," *Erythrina umbrosa*. The latter grows to a much greater height than the "Bocare" and does not afford so dense shade. Why these trees should have attained their high reputation was formerly difficult to understand, but as modern science tells us that they are capable of storing nitrogen in the soil, the matter is no longer an enigma, and it becomes clear that they really do afford nutrimeut to Cacao, but not in the way that was formerly understood. It has been found that many leguminous plants are able to store nitrogen in the soil, and allow it to become available for other plants. The "Immortel" is a leguminous plant, and hence the inference is clear. Other leguminous plants are able to do the same thing, and there can be little doubt that the "Saman" and many others are able to do just as much for Cacao, and for other plants, as the "Immortel."

The wood of the "Immortel" is utterly useless for timber or fuel, and the branches often fall in wet weather, injuring the Cacao trees beneath. Among the numerous timber trees which thrive in Trinidad, it is curious to note that none have been selected for shade purposes which would be useful in other ways, but that such trees exist, is not to be doubted. The planter should note that once such a tree is found and planted, it would materially increase the value of his estate.

Nearly all the trees as yet suggested for shade purposes, possesses no economic value. *Castilloa elastica* has however been mentioned as suitable; but having seen the plant in its native country—Central America—I am unable to recommend it for the purpose, as it appears from our experience that the tree itself requires considerable shade. Timber trees to be grown for timber, would be useless for Cacao shade, as it would be impossible to cut them without injury to the Cacao. It is therefore clear that we should look for a plant which produces an annual crop which can be gathered without injury to the Cacao.

The Hevea's, which produce the Para Rubber of commerce, are likely trees for this purpose, but they are of slower growth than the "Immortel." *Terminalia belerica*, a tree which produces the "Myrabolans" of the markets, might also be tried. Both these trees thrive well in Trinidad and in similar climates.

It will be seen from the foregoing that although it is desirable to procure a better tree than the "Immortel" for shade purposes, it is a difficult task to find one, and the novice had therefore better rest content with what has served so well in the past, and leave experimental trials of new plants to the more experienced.

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Of the "Saman" (Pithecolobium saman) it may be recorded that there is good and distinct evidence of its being a very serviceable shade tree; and it has, in the author's opinion, several points to recommend it in preference to the "Immortel."

Having decided upon the question as to what permanent shade he will use, the planter should make arrangements to plant it either before, or at the same time as the Cacao. The distance and manner of planting will depend a great deal upon the ground, the quality of the soil and the exposure; but the usual distance is from 35 to 40 feet apart each way for the "Boca," &c., and from 40 to 45 feet apart for the "Anauca," and as much as 50 or 60 feet for the "Saman."

For the smaller shade plants, Corn (*Zea mays*), Pigeon or Gongo Pea (*Cajanus indicus*), Tannias, Eddoes, or Cocoes (*Colocasia esculenta*), Castor oil (*Ricinus communis*), Cassava (*Manihot utillissima*) and the Banana or Plantain (*Musa sapientum*), can be used. The Banana or Plantain used for shade is usually planted intermediate between the permanent rows of Cacao. If Cacao is at 15 feet, then Banana 7½ and so on. A variety of Plantain commonly known as the "Moko," or "Jumbi Plantain," is preferred to other members of the family by Trinidad planters for the purpose of affording secondary shade. The fruit of this plant is however considered fit for little else but cattle food, though the green fruit when dried and pounded makes a wholesome, pleasant and nutritive meal, which is a most suitable food for invalids and children. Since the Banana trade has assumed such large proportions in the West Indies, attention has been called to the value of *the Banana* as a shade plant for Cacao. The fruit shipped from Jamaica to the United States is known as the "Martinique Banana;" but in the various Colonies, it appears under different names; in Trinidad being recognised only under the name "Gros Michel." This plant proves to be very suitable for shade purposes in the intermediate stages. The distance at which intermediate or temporary shade plants should be placed apart, is merely a matter of convenience. The skilful will always take care he has enough, and not too much, but as they are all ultimately removed, it matters little really the exact distance they are placed apart, so long as the Cacao gets the necessary shade.

A form of planting at stake may be effected by planting at once a Moko or Gros Michel at the exact distance apart the Cacao is intended to be, and sowing in or near the Banana stool the three seeds; the Banana stool will, with the intermedia e shade crops, give quite sufficient protection to the young seedling, and the costly process of staking with "pickets" is avoide l.

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The after cultivation, *i.e.*, *weeding* or *cutlassing* of a Cacao estate is a work which is done on the average about twice in each year. It is done by task work as a rule and at the rate of 40c. to 50c. per task, or at a cost of about 5s. per acre.

The cost of weeding, of course, depends upon the amount of weeds to be cut, and the better the plantation covers the ground, the smaller number of weeds there will be. Seldom or ever does the planter dream of using the hoe for cutting up weeds, although it may be conveniently used in the younger stages of a plantation, before the roots of the Cacao have taken possession of the surface. Hoe weeding is then much more effective than cutlassing, but great care should be exercised that the surface roots are not injured.

Whatever system is used, the bush should never be allowed to be rolled up so as to cover the stem of the tree, but should be neatly made into winrows, to be distributed over the ground again, when sufficiently decayed.

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CHAPTER IV.

Manuring and Pruning.

MANURING.

TO understand properly when a tree requires manure and when it does not, we require some standard or guide, as to what a Cacao tree in good health and thriving condition really should be like. There should be an ideal or standard of culture and this should be the guide in all important operations. Let us premise therefore, that a tree in good health needs no manure. Such a tree is doing its work well, and to the fullest extent, and therefore to feed it with manure would be like overfeeding a horse, and it would just as quickly get "out of condition." To make the point clear, I will describe what my ideal is of a tree in good health. It is a tree which from its seedling stages has annually made good periodic growth, producing leaves and branches strong and without disease or blight, and one which produces an average crop of fruit without dropping it prematurely, or losing it by attack of parasitic diseases, and a tree which can withstand a maximum of either rainfall or drought, without its general bearing being affected. Such a tree needs no manure, for manure is but food, and so long as it has a sufficient natural supply to maintain it in good health, it needs no artificial substitute and will do its work best without it, and to give such a supply would probably reduce crops instead of increasing them. It must not however be understood that no manure should ever be applied to Cacao, for such would be in direct opposition to the principles and practice of Agricultural Science, and could not be upheld, for when trees show by their state of health that their natural food supply is exhausted, other supplies must assuredly be furnished

The application of suitable manure to trees planted in poor soil, to trees in weak health, and to trees which it is desired should make a more than usual rapid growth to serve some purpose of the cultivator, has the best effect; but the application of strong manures to trees in good health, and in average bearing, would tend to encourage rank and sappy growth which

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would be non-productive and loss of crop would result. A tree, like a horse, can do more work when in "condition" and with less exertion than it can if overfed and surfeited.

Manure may with advantage be applied to a tree, should it be found that the plant has set itself more work to do than it can efficiently carry out (*i.e.*) by setting a larger crop of fruit than usual. In such a case the application would cartainly be beneficial and enable the tree to carry a crop which, under ordinary circumstances and without manure, it would not be able to, but the application of manure to a tree before the fruit is formed, or at any early period of its growth, would probably result in inciting the tree to produce a large amount of branch growth, to the detriment of the fruit, which would probably fall.

It will be seen therefore, that the application of manures to Cacao requires great judgment and should only be done under the personal supervision of a skilful cultivator, or loss may result. Where, however, the plantation will evidently be the better as a whole for the stimulating action of manure, owing to a poor soil, its application may be made general and not special from tree to tree. But when chemical manure is appled it will be best to handle it with the greatest caution. Farmyard or stable manure can always be applied with much greater safety than chemical manure, but its action is not so quickly apparent though its effects are more permanent.

The application of manure is a subject upon which chemists and vegetable physiologists differ in many respects. The chemist is apt to insist upon the manure being buried beneath the soil, or he says much of its value will be lost owing to the dispersion of its volatile properties by moving air, but the cultivator may easily ascertain the best method of applying manures of all kinds, if he studies the life history and character of the plant and the nature and morphology of its organs of assimilation, and moreover, the frequent showers of the tropics prevent any great waste of the volatile constituents. To dig deeply about the roots of a surface feeding plant for the purpose of applying manure would be absolutely absurd, as we should thereby destroy the very organs or mouths, which are needed to take up the plant food presented to them, and which are situated in the proper place to carry out the process to the best advantage. Practices of this kind, are often recommended by newcomers to the tropics who have only had training in the agriculture of a temperate climate. I have seen the practice carried out with dire effect, more than once in Trinidad, and it is quite certain, that although it may be carried out with considerable safety in a temperate climate, it is fraught with the greatest danger in the tropics.

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The destruction of roots which the operation of burying manure occasions, would, in most instances, completely nullify the action of the manure applied, as the broken roots would not have the power, nor the same amount of surface for absorbing food, as when uninjured; and the manure applied, through its coming into direct contact with injured tissue, would tend to destroy the roots by its caustic character, rather than be absorbed by them. That beneficial results follow the application of manure when buried beneath the surface, is of course patent to the novice, but in the case of surface feeding plants, it is only after the roots have recovered from the injuries done by the digging, that they are able to take up any manure which has been applied (*i.e.*) when these organs are again in a condition to perform their proper functions. Even granting that no special harm is done to the trees, there is inevitable delay in the economy of growth, the hazard of losing a flowering season, and consequent loss of crop.

With deep rooting plants, the burial of manure is the most economical method of application, as there can then be no loss of volatile constituents.

If we think over for a while the course which nature has pursued for ages in supplying plants with their food we shall find that the method adopted is purely *surface manuring*. Even the ground the plant grows on, has been almost entirely formed, by additions to its surface, detritus from surrounding lands, by deposits made by flood waters, or by decay induced by the flow of water over its surface carrying with it solvents which are able to disintegrate the materials of which it is composed. For *tree* cultivation, surface manuring is the only method in which the manure can be fully utilized, and we can easily take steps to guard against evaporation or dispersion of volatile principles, by covering the manure with material which will act as an absorbent and thus retain the constituents likely to escape.

In the preparation of land for general crops of an annual or perennial character, such as European cereals, the thorough incorporation of the manure with soil, is of course, carried out as completely as possible; but with this kind of manuring we have nothing to do in connection with Cacao cultivation, as it is not required, and can only be employed where the field is clear of growing crops.

It will be seen therefore, that the course of manuring recommended for adoption, is one which is based upon careful observation of Nature's processes. We cannot command Nature, but can venture to assist her, and we can best do so by following out and understanding to the full, the methods she employs.

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The Cacao tree, although it likes a deep rich soil, is also a surface feeding plant, and the ground around the trees cannot be dug or forked with impunity, for although the tree will stand considerable hardship, it is nevertheless materially injured when the roots are mutilated. There are conditions, however, such as when the surface soil has been thoroughly baked by drought, when it would be beneficial to lightly prick it up with a fork, taking care not to break the roots. A slight forking is however permissible at times previous to applying farm-yard manure top on the surface; having due regard of course to what has been said in the foregoing on the injury caused by the injudicious use of fork and spade. Manure applied to the surface should be covered if possible with a thin layer of earth, but if applied in the form of compost, this is not so necessary an operation, as the volatile constituents of the manure are then in a great measure held fast.

In applying chemical manures of a caustic character, it is always well to mix them with a suitable proportion of absorbent earth, and to cover again with a coating of the same material. The primary object in applying manure is to maintain a due proportion of plant food when land has become exhausted of its natural constituents, or to supply something in which the land is deficient. It is of course patent that with the continued production of annual crops a large quantity of material is removed from the soil, and this must be replaced either by nature, or artificially, or the crop will fall short. Farm-yard manure takes a foremost position for this purpose amongst all others, and long continued practice shows that when properly applied it is of the greatest value to the land, not only for its manurial properties, but also for its mechanical action upon the soil, and moreover, it can never be as dangerous to use as chemical manures, which are admitted to be decidedly hazardous when applied by unskilled labour. By unskilled labour I do not mean the peasant or farm hand only, but I refer to educated people who take up the business of agriculture without due study, acting under the impression that they were "born" to till the ground.

In some cases quick lime becomes a powerful ally to the cultivator, but on the other hand its undue application tends to exhaust the soil of valuable constituents, and therefore it should always be used with great caution. In nature, manure is given to the roots of trees by the decomposition of vegetable and mineral substances, and is carried downwards by rain water, worms, and other agencies. Rain water itself also provides a certain quantity of plant food in solution. The plant or tree does not however, obtain all its food from the soil, as the

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surrounding air provides it with a large portion, which is taken up in gaseous form by the leaves. It should therefore be the aim of the cultivator to maintain on his trees as large a proportion of healthy leaves as they can carry. Whether the food is taken up by the roots, or by the leaves, it is in the latter organs that all the material necessary for the purposes of growth and reproduction is formed and distributed. The leaves are in fact the Laboratory of the plant, in which all the most important changes of the vegetable fluids are carried out.

The importance of maintaining at all times a healthy crop of leaves, cannot be over estimated; and for this reason a system of pruning should be adopted by which they are made to distribute themselves with great regularity over the branches of the tree, so as to place them in a position to carry out the work they are called upon to perform.

PRUNING.

The act of pruning is popularly supposed to cause the production of fruit. That properly carried out, it has this effect, is not to be doubted, but the effect is not so direct as is often assumed.

Given a young tree in good health, and with a single stem, the pruning should commence by the regulation of the *primaries*, or first branches made by the tree. There should, as a general rule, be only three, or at most four primary branches left on the Cacao tree. These should be encouraged to extend themselves laterally, as they have a natural tendency to do, and should be encouraged to develop at regular distances the *secondary* branches. The *tertiary* branches should also be encouraged to grow at regular intervals.

In the primary stages, pruning should be performed before the wood becomes sufficiently hard to require the use of knife, by the method known as "pinching." This is carried out with thumb and finger, and all succulent shoots not required, can be headed back or "stopped" by this means. At all times, it should be the endeavour of the pruner to maintain the tree well balanced (*i.e.*) it should not have one branch growing more rapidly than another, so as to make the tree appear lop-sided from any one point of view. Many of the older cultivators do not regard this point sufficiently, in carrying out their pruning operations, and many branches are left, owing to their being bearing branches, which for the permanent security of the tree, for its general appearance, and for its bearing qualities, should be removed. It is much better to check at once the tendency of a tree to assume an irregular and uncultivated form, than to allow a branch grow for a time and finally be compelled to remove it when of large size.

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The pruning of a tree should be conducted with a view to the production of fruit. Unless we have a plentiful supply of good healthy leaves, evenly distributed over the tree so as to obtain a maximum of the light and air they require, we cannot expect to secure large crops of fruit, in fact unless the machinery is in good working order and the supply of fuel abundant, we cannot expect a good output. The leaves and roots represent the machinery; and water, sunlight, air and manure, acting together, may well represent the fuel supplied.

The branches of a Cacao tree therefore, should be evenly distributed, so that the leaves they carry may be maintained in good health, and just thinly enough distributed to admit sufficient sun and air to mature the fruit.

It should be a rule when pruning that too many branches should not be removed at once. It is a mistake to prune heavily at any one time, as it gives the trees too great a check, and causes too great a disturbance of the growth. The effect of heavy pruning may be seen by the large growth of young shoots which appear at or near the place where branches have been removed. These in most cases, are quite useless and have to be removed, causing a waste of plant energy, for if properly directed the material used in this growth would have considerably added to the health and strength of the tree. In pruning neglected trees, the first thing to be done, is to cut out useless wood, or wood which can never be expected to bear or to produce bearing branches, or again, wood that is diseased or cankered. The next thing is, to equalize or balance your trees, and last, to thin out the branches and foreshorten them where required.

In removing branches the greatest care should be exercised not to make jagged, ragged, splintering or slivering cuts, but to make clean and even cuts close to the wood and near to a bud or young branch into which the sap will be presently directed if the operation is well performed.

The young branches which are often found growing erect (commonly called *gormandizers* from the rapidity of their growth), are productions which show that the parent stem, as it stands, does not provide sufficient channels for the expenditure of the sap supplied by the roots, and in consequence this sap provides for itself an outlet and expends itself upon the production of rapid growth in a single direction. It shows that the channels for the conveyance of sap are clogged or contracted, and that the amount of sap produced cannot pass into the more matured portion of the tree. It is also an effort of nature to recover itself from hard work. Every physiologist knows that unless branches are produced, roots cannot be, and the production of root is in exact ratio to the production of branch, and

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the more these are allowed to grow the larger amount of root power the tree will have; but the cultivator should see that this power is judiciously expended by directing growth in the required channel. When however, a tree is bearing fairly in proportion to its size, it is better to remove these branches as they appear; as it is certain that by affording free opening for the absorption of sap, they rob the crop of the full amount of nourishment it should obtain, and the productive power of the tree is seriously affected. They should be removed however, as they appear, and not be allowed to grow to a large size and then removed, as that practice would simply be a waste of the material used up in producing them, instead of using it for the production of fruit. It is a bad and slovenly practice to allow suckers or gormandizers to be pulled off. They should always be removed with a sharp knife, when the wood is too hard to allow of their being "pinched" between the thumb and finger.

In cases where the Cacao tree has evidently become somewhat worn out or partially barren (*i.e.*) its bearing wood shows evident signs of being out of condition, it is a good plan to make use of a "gormandizer" to supply a new bearing head to the tree, and give it a new lease of life. This can easily be done if the most suitable is allowed to grow, and trees can be more quickly re-juvenated by this means than by any other.

By allowing one of these branches to grow from a suitable situation and by treating it in a similar manner as we would a young plant, it is possible to re-juvenate and bring again into bearing, trees which if left to themselves, could not be expected to yield any crop. It is really wonderful in what a short time this operation can be completed if skilfully carried out.

After the young tree thus formed has assumed fair proportions, the older wood should be carefully and gradually cut away, but not all at once, as heavy pruning always seriously interferes with the growth of the tree. If pruning is done with a saw, the wounds should afterwards be smoothed over with a sharp knife as they always heal better if thus treated, and besides, they should be covered with a coating of tar and clay or other antiseptic dressing to hinder the entrance of parasitic fungi, and the Cacao beetle from laying its eggs in the wounded parts.

A mixture of coal tar and clay of the consistency of paint may most conveniently be applied to all wounds. Pruning with a blunt cutlass, knife, or Cacao hook, should never be allowed. The instruments used should be those which are able to carry a keen edge, and the pruners should always be supplied with the means of sharpening their tools without leaving the field.

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The time for pruning the Cacao tree is the subject for frequent discussions, on account of the influence which the moon is supposed to have upon the flow of sap, &c., &c. Such discussions are interminable. One assumes that the sap, like the blood of an animal, courses through the vessels of a plant periodically, and that the moon has direct influence upon the flow. Another concludes that a tree has more sap in its branches at full moon than at other times, while others declare that insects attack the trees more at full moon than at other times. In nearly all these cases the *premise* is erroneous, and therefore the conclusion cannot be a correct one. If the moon has any influence, I may at once confess that in all my practice, I have never discovered it. I would ask those who assert that the moon has influence on the condition of a Cacao tree, to prove it by something more than mere assertion, and to allow me the priviledge of dissent until such proof is made known. I do not desire any one to accept my opinion, *that the moon is entirely a negligible quantity;* unless they choose to do so, but I object entirely to be forced to accept the opposite conclusion. If it pleases certain planters to waste time and money (in my opinion) in waiting for certain phases of the moon before commencing to prune their trees, to gather their crop, or to sow their seed, that is their affair; but I cannot for a minute sanction or teach such a doctrine, as I believe it to be incapable of proof. I know that there are many men for whom I have the greatest respect who regulate the work of their estates, in some part at least, by the phases of the moon; but I cannot see that it would be right on that account, to dispense with the call for scientific proof of the theory they adopt, as without this proof, the theory is to be regarded as one upon which it would not be safe to rely.

Whether the moon has any influence or not, had better for the present be left an open question, not that I have any personal doubt upon the matter, but still the question is one, which take it how you will, has little or no influence upon the progress of cultivation, as each individual may adhere to own pet theory without being placed at any great disadvantage. In over thirty years practical work in the temperate zone as well as in the tropics, I have carried out hundreds of experiments bearing on the subject of the moon's influence on plant life; and yet in none of these have I found anything to support the conclusion that the moon was in any way a controlling power over the operations of the Agriculturist.

The season for pruning is a different matter from the time for pruning. The one fixes the time of the month, while the other fixes the time of the year. It is taken as an accepted rule that in established Cacao, pruning or "trimming" as it is called in Trinidad is best carried on at the close of "crop time."

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This practice is a reasonable one as the trees are then devoid of both flowers and fruit and therefore suffer no possibility of injury.

On the first class estates where cultivation is carried out in the best manner, the tree should annually receive attention in the matter of pruning, &c. Every tree should be visited and carefully examined. On many estates in Trinidad it is the practice to prune only at intervals of once in three or four years. Such cannot be considered good practice, as I have before shown that the less pruning done to a tree at one operation, the better.

It should be remembered that a cut made in pruning a tree, is just as much a wound, as a cutting of a finger from the human body, and that although the plant may repair the injury to a certain extent, still the wound remains, and produces a certain disorganization of tissue, not seldom resulting in decay and death.

In making cuts care should be taken, always to make them at an angle that will shed the rain from the wound, as nothing is so conducive to the entrance of fungi, as the maintenance of a constant state of humidity on a wounded surface.

The cultivator should be careful in removing and burning as far as possible prunings from the ground. If left to rot upon the plantation these prunings become the home of innumerable wood destroying insects, and beetles which are inimical to the welfare of the Cacao plant. There is nothing like tidiness and cleanliness in any cultivation, and departure therefrom is sure to produce sooner or later its concomitant evils.

The practice of pruning, the way to hold knife or saw, cutlass or cacao hook, cannot be taught by any writer. The inexperienced should seek practical instruction, and even then it requires a considerable amount of time and experience ere he will be able to handle his tools with dexterity and precision.

The difference between a slovenly cut and a clean cut are at once apparent when the work is compared, and no workman should be permitted to practice pruning upon valuable trees, until he is well accomplished in the practical use of the tools employed.

The skilful pruner can, by a proper handling of his tools, and cutting back to buds situated in the positions from which he desires a branch to come, form the tree at will into the shape he requires, and the plantations in which such skill is exhibited, will always present a tidy and cultivated appearance, while those treated by the negligent and unskilful pruner will always look untidy and irregular.

Good maxims for the cultivator are, "prune little, but prune often; prune carefully, but prune with decision. Prune for a large amount of healthy leaf surface, and a crop will come."

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CHAPTER V

Roads and Draining.—Temperature and Rainfall.

ROADS.

HE laying out of Roads for a Cacao estate should always be one of the first considerations of the planter. If the crop he grows is difficult in the first place to get to the curing house, and in the second place difficult to get to the market, it will easily be seen that, what would in other cases be a fair amount of profit, can owing to difficulty of transport, be easily frittered away. In laying out an estate therefore the proprietor should reserve traces at right angles to each other for roads to be used for the purpose of collecting his crop, and ascertain that the land he selects is near to a good main road or railway, so that his produce can be easily placed upon the market.

With estates on the plains, roads are of course easily made, but if situated on a hill side, to make roads is somewhat more difficult, but still even here it is better to allow plenty of space and make good roads at once; so as to give easy access to every part of a plantation. Hill side roads are not difficult to make, once the principle is understood, but, as with pruning, the work can hardly be described, and is best learnt by practice under the tuition of an experienced hand.

The land taken up by roads, is by some planters thought to be wasted, and many are satisfied with planting the whole ground without providing anything which can be definitely called a road. The economy of having a proper system of roads is however easily understood by those who have been used to systems of the kind, and the loss on the number of trees which would be planted on the land occupied by a road *is more than recouped to the planter*, by the accessibility the roads afford when pursuing any of the operations of cultivation or harvesting crop. We often see plantations crowded with trees among which the mule or donkey is allowed to struggle with its "panniers" or "crook" when taking off crop; regardless of the many wounds

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which are made in the bark of the trees, and the diseases thereby induced. Good roads should lie at short distances apart and animals should never be allowed among the trees.

The distance at which roads should be made will have to be determined entirely by the lay or aspect of the plantation. In flat land any distance from 4 to 8 chains may be used; the richer the soil the nearer the roads should be together.

In Draining, as in Pruning and Road-making, only general principles can be laid down. All land of course requires draining of some kind or another, but no one can give definite instructions for draining an area until it is understood what amount of drainage that particular area requires. Land situated at a low level will of course require much more attention to rid it of superabundant water than will hill-side land, and each area must therefore be treated according to its own requirements.

The object of drainage is, to rid a Cacao estate of stagnant or superabundant moisture. Flood waters from a river, so long as they do not cover an estate for too long a period, do but little practical harm, indeed in some districts they are looked upon as doing a large amount of good, by bringing down and depositing upon the surface a certain amount of manurial constituents.

Drains made in any kind of cultivation should always be made V shaped with a narrow bottom. The practice of making drains with upright sides, which fall in and choke the drain, cannot be too strongly condemned, and in no case can they be recommended; and the depth and width of the drains should be regulated by the circumstances of soil and situation.

Drains should never be made straight in coming downhill, as when so made the wash becomes enormous, especially if the descent approaches in any way an angle of 35 degrees, but in flat land the straighter they are made the better.

The site for a plantation should always be selected where there is a good natural main outlet for drainage waters.

Under draining with pipe, rubble, or bush draining is I consider utterly useless in Cacao cultivation, as it stands to reason that such drains must very early be filled by the roots of the trees (both Cacao and shade trees) and that the action of the drains after the first few months will be stopped by the roots finding their way into them in search of moisture. The theory is good. but the practice is quite unsound with regard to

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Cacao. It is different in lands on which cereal crops are annually cultivated, for there the roots seldom or ever reach to the drains during the period of growth, and consequently the drains themselves work from year to year without let or hindrance. The planter should therefore trust entirely to his surface drainage and make that system do the work to the best advantage.

TEMPERATURE.

The temperature required for the growth of the Cacao tree will be best seen from the records of the temperature as taken at the Royal Botanic Gardens, the temperature and humidity being somewhat similar in the various Cacao districts.

Meteorological Results Royal Botanic Gardens, Trinidad.

	Inches of Rainfall.	Mean annual relative Humidity.	Temperature mean Maximum	Temperature mean Minimum.	Temperature mean Annual.
Record for 1887	64·09	79·	85·90	69·00	77·40
„ 1888	65·44	80·	87·50	69·70	78·60
„ 1889	73·79	77·	87·70	70·10	78·90
„ 1890	82·90	79·	86·10	69·00	77·50
„ 1891	53·74	76·	87·80	70·10	78·90
„ 1892	91·14	80·	87·02	70·02	78·70
„ 1893	92·49	80·	87·44	68·58	78·01
„ 1894	52·21	78·	87·80	69·10	78·45
„ 1895	62·23	76·	87·80	69·50	78·60
„ 1896	66·45	80·	87·84	70·31	79·07
„ 1897	77·68	80·	87·91	70·35	79·13
„ 1898	57·63	80·	87·60	69·20	78·40
„ 1899	46·76	75·	89·30	69·50	79·40
13 years average ...	68·19	78·	87·51	69·57	78·54

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It will be seen from the table given that the average humidity is 78·83, taking saturation at 100. In some districts of the Island the amount of relative humidity or moisture suspended in the atmosphere is probably much greater than at the Royal Botanic Gardens. It may therefore be held that what is indicated for this district, is the lowest permissible amount for a district suitable for Cacao cultivation, and that such crops would be benefited by a greater amount of humidity.

The annual Rainfall at the Botanic Gardens for the past twelve years shows an average of 71 inches, but in the longer period of 35 years this average is reduced to 65·49 inches.

In my experience, humidity is a much more important feature in plant growth than temperature alone, and few plants suffer more than Cacao at periods when the year is deficient in moisture. Even in the driest weather in Trinidad the Hygrometer shews that during the later portion of the night and early morning, the moisture in the air closely approaches to saturation, and it is only the readings of the period between 10 a.m., and 4 p.m., which reduces the record to the average of 78.

Cacao can stand a certain amount of severe drought for short intervals, but districts which are subject to *continued drought*, are certainly *not suitable for the cultivation of the Cacao tree, as under such conditions the Cacao tree will certainly die.*

RAINFALL.

Countries in which the mean annual rainfall is greater than in Trinidad may not possess the same humidity, and therefore are not as suitable for the cultivation of our plant, and countries on the other hand which exhibit a smaller annual rainfall may be suitable for Cacao cultivation, owing to the presence of the requisite amount of humidity; for in no country is the humidity fully determined by, or coincident with the rainfall, as it is often influenced by many other outside conditions. On the south side of the Island of Jamaica for instance, although a similar temperature prevails as in Trinidad, the humidity shows a remarkable divergence from our record, and in that fact shews plainly that this district is unsuited for the growth of Cacao. Though there are other situations in that Island where the requisite humidity can be obtained and where the tree thrives exceedingly well and produces large crops of fruit.

The planter must not take it for granted therefore, that because he is in the West Indies, Central or South America, etc., etc., in a climate exhibiting a *temperature* similar to Trinidad

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that he can rely upon such a situation or climate as being suitable for Cacao, for he cannot do so, as he may find to his cost if he attempts the venture. Having thus learnt what the Cacao tree requires in the matter of moisture or humidity the planter must examine for himself and depend on his own judgment in selecting a spot for a Cacao plantation, especially if it happens to be in a country where the cultivation of that product has not preceded him.

In the West Indies, as in other countries the higher the elevation the cooler the temperature, and the greater the moisture during the hours of darkness, and in hilly situations in well sheltered positions Cacao has been found to thrive owing to the presence of sufficient humidity in places where the temperature is very much below the mean annual of the finest Cacao districts.

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PART II.

CHAPTER VI.

Picking.

IN picking Cocao it is the practice to make use of an instrument known as a Cacao hook, which is manufactured for the purpose.

The instrument is made of a shape to be used either by a push, or pull, or by a side cut, and when kept well sharp, and affixed to a light bamboo rod, serves admirably for collecting the pods from the higher branches of the Cacao tree, but a sharp cutlass or knife is used for taking the pods from that portion of the tree within reach of the arm. Care should always be taken not to cut too close to the "cushion" or point at which the Cacao pod is borne, as the tree presents a succession of flowers and fruit from or near the same point or "cushion" each season; and if the part is wounded by a cutting instrument or bruised by a blunt one, the supply of flowers, and consequently fruit, will be reduced during the following season.

The pods or fruit of the Cacao tree should not be harvested until they are properly ripe, and it requires a considerable amount of practice and experience to judge when the pod is fit to be gathered. If collected when over-ripe, or when insufficiently ripe, the quality of the produce is much affected, as it assuredly results in making an uneven sample. Only skilled and careful workmen should be employed for this work, as the planter will save a large amount of after picking and sorting if the harvesting is properly done. It is much better to go through the plantation and pick "little and often," and secure good samples, than to pick green and over-ripe together and have afterwards the trouble of sorting the picking, to eliminate the inferior beans.

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Where there is considerable variation in the kind of pods produced, it is better to sort the pods before shelling or breaking them rather than make a mixture composed of the several varieties of beans cultivated, as these are known to require different treatment during preparation for market. For instance *Calabacillo* strain, is known to require different treatment to the *Criollo*, and the *Criollo* again a different treatment to that required by *Forastero*.

The pods when thus collected should be placed in separate heaps. By some cultivators they are left a day or two before being opened, by others they are opened at once and the beans sent on to the curing-house, or *Boucan* as it is called in Grenada. The latter practice would be our choice, as it enables the planter to secure his produce from the weather and from the depredations of rats, squirrels and the not infrequent Cacao thief. In the one case the labour is performed by a few pickers and carriers, and the breaking has to wait until sufficient material is secured for a single fermentation, in the latter more hands are required but the picking of a single day is fermented by itself.

On large Cacao estates however it is almost impossible to gather or harvest Cacao without having some over-ripe pods and pods with growing beans, among the crop. These should be separated when the breaking takes place, if not before discovered, and treated by themselves, as such material can never make first-class Cacao.

The wages paid in Trinidad for picking Cacao is from 40 to 60 cents per day and is performed by experienced hands.

SHELLING OR "BREAKING."

This operation, as before shewn, is sometimes done in the field and the produce carried home in bags, or the pods are first carried, and then broken at the curing house. The first practice is the most common, although the latter is to be most commended, as the decaying shells or pods when left on the field, are a fruitful source of disease.

The operation of shelling or breaking is done with a cutlass or large knife. A cut is made round the middle of the pod, taking care not to allow the tool to go through the shell so as to injure the beans. The pod is then broken in the middle by a sharp jerk, and the beans are taken out and separated from the fibrous tissue of which the *placenta* is composed.

In Nicaragua the pods are generally brought in and broken under cover near the curing houses, and the empty shells are put into yards to ferment, and to be trodden into manure by cattle, pigs, &c. There is thus little danger of the spread of fungoid diseases, as no rotten pods are left on the

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field. The pods are broken without the aid of either cutlass or knife, by being dashed on a large hard wood log, upon which the operator sits; and the beans are picked out and taken to the sweating boxes, and the shells carried away, by attendant women and girls.

If superior samples of Cacao are intended to be made, it is very important that the breakers should be instructed to carry out strictly a sorting process which will separate the ripe from the unripe beans, and the different varieties from one another, for it is possible to make a much more even sample, by giving due attention at this stage, than by any other means, for from the appearance of the sweet pulp surrounding it, the condition of the interior of the bean can be correctly estimated.

Among the planters of Trinidad there are many who are well alive to the importance of making improvements in the process employed for curing Cacao, but as a rule their efforts are met by considerable prejudice in favour of the old *rule-of-thumb* methods, and any one trying to make an improvement, is subject at times to no little ridicule on that account, from those who should be among the first to know better, and therefore it is a hard fight to get required reforms into working order. With the small settler it is doubtful if the classification of produce could be carried out to any real advantage, so long as each producer undertakes the curing of his own crop; but were a system of central factories established, a system of classification could be efficiently carried out, and the general character of the produce greatly improved. Large owners hold generally the view, that a system of classification, does not pay, owing to the increased cost of labour necessary to carry it out. Whether this is a true view, or not is best shown by the fact, that in the markets of the world we always find that we must produce a first class article to obtain a name, and to obtain a name, means to obtain a profit above our competitors; but we certainly can never obtain a name unless we make a first class article. To make a first class article in any trade or business, is well known in the long run to pay much better than to make ordinary produce. There can be no doubt that many improvements in the curing of produce *can be* effected if the necessary study is given to the subject by intelligent men, and the curing of Cacao certainly forms no exception to the rule. Classification of produce of course would be governed greatly by the character of that produce, but still even with crops of the most mixed character, it is still possible to prepare produce for the market which would exhibit a great improvement on the ordinary outturn, by careful selection of the pods in the field or better, by selection of beans during the process of shelling.

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Some will argue that it pays them better to make (what they consider) an inferior article, instead of making (what they consider) a superior one. Now the facts are, that the so called superior article is one which has gone through a large amount of fermentation, and the so called inferior article, is one which has been treated to a lesser amount of preparation. There cannot be the slightest doubt that the prepared article is of the best flavour but if the market demands at times a lower scale of preparation it will of course generally be to the interest of the producer to supply the quality which is in demand, whatever the *ideal* may be of *superior* or *inferior* quality, but he should nevertheless not lose sight of the fact that a *superior* article is always saleable, while an *inferior* article has at times to suffer in price for the want of a buyer.

The quality of Cacao however depends much more largely upon the special kind of variety grown, than upon the quality of the land, or the amount of preparation it receives. Of course preparation can be well done, and badly done; but, given a bad class of Cacao, no preparation whatever could ever make it a first class sample, it may make it better, but never first class. For instance all the knowledge of preparation available in Trinidad would not suffice to make a sample of Trinidad Cacao into a sample which could be identified with that of Ceylon or Java, for the reason, that the class of Cacao itself is essentially different; and per contra, it would puzzle the Ceylon planter to turn out a sample to match that of the best Trinidad unless on estates where the Forastero variety has been introduced; and Trinidad could only turn out a sample like the Ceylon produce, by growing the exact strain which produces that class of Cacao.

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CHAPTER VII.

Fermentation.

T the latter part of the year 1889, being desirous of obtaining information from Trinidad planters of the various methods in use for conducting an operation which nearly every one of them considers of such great importance in the proper preparation of Cacao beans for the market; I suggested to Governor Sir William Robinson, K.C.M.G., that it would be a useful measure to offer prizes for the best essays on the fermentation of Cacao. The proposal was approved and the prizes were offered. The first prize was awarded to the late Dr. Chittenden, the second to Mr. Crichlow, and the third to the late Honourable Eugene Lange.

The essays were published in the *Agricultural Record* and incited a large amount of public attention and criticism. The Essays were printed as an appendix to the first Edition of this work and proved useful in showing the diversity of opinion which existed with regard to the manner of conducting the process. It cannot be doubted however that although the method varied to a considerable degree, yet nevertheless each was capable of producing good Cacao; showing that in essentials all were agreed, or this result could not follow.

It will be convenient in discussing fermentation to consider: 1st, the necessity for the operation. 2nd, the change brought about, and 3rdly, what causes the change. 4th, general results.

1st.—The necessity for the operation.

We find that there are countries growing Cacao where the practice of fermentation is not carried out in the same manner as in Trinidad; but it is an admitted fact at the same time that these countries obtain a low value for their produce. Fermented Cacao has for years past brought in a much better price than the unfermented, and it is therefore only reasonable to suppose that the practice of fermentation would be adopted in some one of its forms by all the largest producing countries. It is a certain fact however that of late years there has been a large amount

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of enquiry for Cacao which is but slightly fermented, or not fermented at all and in consequence of this, so much importance has not been attached to the methods of fermentation as formerly.

The process is however one upon which in a large measure the commercial value of the produce depends, and no matter what variety of Cacao is grown, be it Criollo, Forastero, or Calabacillo, its value will be relatively enhanced if a proper system of fermentation is carried out *(i.e.)* if it has to go to certain markets, for others little is required. The systems or methods extant for fermenting Cacao are innumerable, though there appears the same underlying principle in all of them.

It is necessary first of all to remove the pulp surrounding the berry, so as to allow the bean to dry—how we do this is a matter of little moment so that we do it effectually—but if in removing it, we can at the same time effect improvement in the substance of the kernel itself, we shall be carrying out at one operation what we should find very difficult to do if carried out separately. For instance, if we first removed the pulp, we should not afterwards be able to change in any way the substance of the kernel. Fermentation is considered by all operators as the easiest way of effectually getting rid of the pulp, and it is also probably the only reliable way of improving the character of the interior of the seed.

It has been held that little or no fermentation is necessary for some markets, and that the bitter flavour and the purplish colour of the bean do not require alteration; but those who hold these views in Trinidad are probably still in the minority although perhaps on the increase. Fermentation is a necessity for the quick removal of the pulp, it is a necessity to allow of the bean being quickly dried, and it is a necessity for the purpose of altering and improving the character of the substance of the bean, and to improve the colour and flavour of the produce.

2nd.—The change that is brought about.

The changes that are brought about during the process of fermentation are in the exact ratio of the time given to the process, and the manner in which the operation is carried out.

What is sought to be attained is, the complete removal of the saccharine pulp which surrounds the seeds, for the purpose of allowing the seeds to dry in a short time and to get rid of an amount of superfluous material which would otherwise remain as a waste product attached to the cured bean. Besides, there is a change in the bean to be brought about. Some are of the

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opinion that the changes of a certain kind take place, while others hold that changes of an opposite charater are developed, as was clearly shown by the Essays of 1889. All are however fairly agreed that a change of some kind is necessary and different operators disagree only as to the exact manner of bringing about such a change. One object of the operator is to change as far as possible the colour of the bean from a harsh purple to a chocolate or cinnamon colour by fermentation, and this change is brought about by the process in a varying degree. The original colour of the interior of the beans has however much to do with the final colour of the finished article. The white seeded Cacao of Nicaragua takes only 48 hours to become a fine "cinnamon" brown in colour, and the strains of Cacao that have light coloured seeds are always those in which the finest colour and break is produced. The true Creole of Trinidad, as found wild in our forest has white seeds and compares well in shape and form with the Ceylon and Java produce with which it is now said to be identical. Mr. J. R. Martin, reporting on Cacao to the Planters' Association of Ceylon in 1891, has a paragraph as follows:—"The break of West Indian growths, so far as I had an opportunity of observing, was invariably very dark brown or purple; which indicates that the Cacao is of the Forastero variety, and every Cacao planter knows that no care or curing will alter this characteristic." Mr. Martin here refers to the colour of the interior of the bean. It is very clear that no preparation can ever produce the colour from a purple bean, which can be obtained from the white seeded varieties but still the purple colour of Forastero can in a great measure be controlled by properly managed fermentation.

Another change which is brought about by fermentation is the hardening or toughening of the shell of the bean. This is desirable from the point of view that it preserves the interior when the shell is kept entire. If the shell of the bean is brittle, it suffers much during transport to market, and the interior becomes liable to rapid deterioration in consequence. It has been held that the operation of sweating or fermenting is simply one of "malting" (*i.e.*) one by which the starch of the bean is changed into sugar by the act of germination, but I cannot find that this theory has found much favour, and I am of the opinion that it is impossible to make a high class product from germinated Cacao.

3rd.—What cause the Changes.

This is a difficult question to answer, and in fact can only be answered after a full study of the Chemistry of Cacao. There was until recently no accurate data at hand on this most

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important subject. A partial analysis by Professor McCarthy appeared in one of the annual reports of the Royal Botanic Gardens some years ago which simply gave the constituents of the fresh bean, but nothing further was forthcoming until in 1897 Professor J. B. Harrison, M.A., Government Analyst of British Guiana, took up the question and performed a lengthy series of analyses, which have afforded a very large amount of valuable information. Professor Harrison has been good enough to allow me to make use of this information and it appears, as recently revised by himself, in the chapter which deals with the Agricultural Chemistry of Cacao. (Chapter 12.)

These analyses show clearly the constituents of the fermented and unfermented bean, and the changes caused by the operation.

It is clearly desirable, in the interests of a Country producing 20,000,000 lbs. of Cacao per annum, to know the basis of the methods of fermentation which are in use, and the changes which occur in the product; and the planter will find interesting information on these points in Professor Harrison's work.

Professor McCarthy's analysis, ran as follows:—"In two ordinary varieties of Cacao lately analysed fresh from the pod, the fat in one was only 18% while in the other it was over 28%. Theobromine being in nearly the same proportions."

A set of analyses are to be found in the pages of Tropical Agriculture by P. L. Simmonds, but these, as the author states, are not flattering to Chemical science.

An analysis by Professor Church in "Food" (South Kensington Science Hand-book) runs as follows:—

	In 100 parts.	In 1 lb.
Water	5·0	0·350 grs.
Albuminoids	17·0	2·315 ,,
Fat	51·0	8·070 ,,
Theobromine	1·5	0·105 ,,
Cacao Red...	3·0	0·210 ,,
Gum, etc.	10·9	1·326 ,,
Cellulose and lignose ...	8·0	1·122 ,,
Mineral matter	3·6	0·252 ,,

Professor McCarthy found 18 and 28 per cent. of fatty matter in two samples of fresh Cacao—but this apparently might represent an amount of 50 per cent. in the cured bean, in consequence of the removal of moisture and the pulp and mucilage from the outside of the bean, which material goes to make up a large proportion of weight, and would reduce the percentage of fat in proportion to the total weight of fresh bean.

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An examination by the author, of beans fresh from the pod showed the following :—

	ozs.	
Total weight from inside pod—No. 1		=3·75
Weight of pulp and testa or skin of seed removed	=1·65	
Kernel (clean)	=1·75	
		3·40
Loss during operation		·35

	ozs.	
Total weight from inside pod—No. 2		=5·40
Weight of pulp and testa or skin of seed removed	=2·40	
Kernel (clean)	=2·40	
		4·80
Loss during operation		·60

The pods were ripe pods, the entire contents were removed from the shell after it was opened, and then carefully weighed. After weighing the pulp, the *testa* or skin of the seed was removed and the waste and cleaned bean again weighed as above. It will be seen that the pulp surrounding the bean, with the *placenta*, weighs nearly the same as the cleaned kernel, and therefore if Mr. McCarthy's analysis was taken from the fresh bean, pulp included, it is no wonder that he did not get a higher percentage of fat than 18 and 28 per cent. Taking the average between these and allowing the difference of 100 per cent. for the weight of waste on the fresh beans, we have 46 per cent. of fat in the fresh bean according to that analysis—which approaches that of an average sample of cured Cacao—Church's analysis. The difference in the percentage found by Professor McCarthy in his two samples would be easily accounted for, by the moisture contained in the bean, or in the mucilage surrounding the bean being greater in the one case than in the other. It will I think be evident that we are well on the way to ascertain the "cause of the change" once we have digested the elaborate and careful analyses made by Professor Harrison. These analyses necessitated over three hundred operations, many of which had to be repeated, and he is to be highly congratulated on his valuable contribution to our knowledge of the Chemistry of Cacao.

4th.—General Results.

If we examine carefully the underlying principle (often unknown to the operator) which leads to certain results in all the old methods of sweating or fermentation, we shall find that although the detail of procedure is somewhat different in each case, yet there is a decided similarity in the result. We find

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one operator holding one opinion, the next holding another, but after all their productions are about equal, allowing the observant man the priority he gains by the use of his judgment, or his common sense.

Practice will tell the planter the condition to which he must bring his beans by fermentation before he attempts to dry them; and until brought to this particular condition, they cannot be considered properly cured or fermented, so as to furnish a well cured sample when finished off. The condition into which the bean should be brought, is well known to the generality of planters, and we find them making sections of the beans to ascertain whether the fermentation has been regular and general but to describe the particular condition is a hard thing to do. The best I know of is that of the late Dr. Chittenden in 1st prize Essay. He says:—"At this stage if "fermentation has been properly established, the cotyledons are "found separated and the vinous liquor of the pulp, which "passes through the membranous covering, occupies this space "as well as the cavities between the convolutions." This it is "which has so marked a physiological influence and affects its "flavour, the bean being, as may be said, "stewed in its own "juice." What is here described I believe to be literally true, and unless we can stew the bean in its own juice, or absorb the constituents of the pulp through the membranous covering in some manner, we shall never properly ferment Cacao or change the character of the interior of the bean.

The above may be taken as the condition to which the bean is brought by the moist fermentation of Cacao, but there are other methods used which produce similar results Dr. Chittenden says also, "The *conuquero* puts up his beans to "drain and forthwith exposes them to the sun for say five or "six hours, then heaped and packed up they *sweat* afresh until "the following day, when they get five or six hours more sun "and so on." Again, "another contrivance of the small "grower, is that of bagging the Cacao at the end of the day, "whilst still hot from exposure to the sun and to *sweat* it "during the night."

This is the practice of the Venezuelan planter, and is described in Sir William Robinson's Pamphlet (1890)

The prime object of sweating or fermentaton therefore appears to be, to change the inside portion of the bean, by absorbing into it products obtained from the fermenting pulp, and where this is not fully accomplished by any of the methods, the bean is classed as unfermented, and the product is generally of lower value.

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It is understood by the experienced planter that some varieties of Cacao take longer to cure than others, that some are more bitter in flavour, and that some have a more tender skin than their neighbours. He knows at once that beans of the *Criollo* type do not require nearly as much time to "stew in their own juice" as *Forastero*, or *Calabacillo*, and he knows when each has reached the proper stage of preparation needed previous to the final drying, but the why and the wherefore of the variation of time in reaching this stage is, I believe, as yet a matter of doubt even among the most able. That the difference in the membranous texture of the outer covering of the bean bears a material part in influencing the time necessary for fermentation cannot however be doubted.

There is a point however in this question of fermentation which appears to have been but little studied. The Cacao bean of course possesses a living principle or embryo like all other seeds, and it is well known that this principle can easily be destroyed, both by exposure to dry air, and also by an excess of moisture. The greatest care is always taken by cultivators to avoid an alternation of wet and dry periods when putting seeds to grow, as it is known that this means sure death to the embryo in the first stages of germination, for once a seed has started to grow, a short dry period readily kills it, and so also does an excess of moisture. In the so called fermentation of Cacao, we find the operators adopting both of the methods which are so destructive to the vitality of seeds, for it is well known that the *vitality of the embryo* of the Cacao must be *completely destroyed*, or it cannot become cured Cacao. The Cacao bean however does not need fermentation for the purpose of destroying its vitality, for simple drying invariably destroys the germ. It is a well known fact that seeds from many members of the same family are very difficult to preserve for any length of time, owing to their vitality being easily destroyed by contact with dry air. Therefore it is not simply the death of the embryo which is needed, neither is it the "malting" process which has been considered as the basis of the process of curing. To malt a seed, it must germinate and grow, and its starch must be changed into sugar. It is not necessary however to allow the Cacao bean to germinate at all to produce a good sample, for, though a fair sample may be made of germinated beans if the process is not too far advanced, it is much better that the bean should not germinate to the extent which allows the *radicle* to pierce the *testa* of the seed, though it is certain that Cacao may be much more quickly cured if germination is allowed to take place previous to fermentation, as the absorption by the

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passage or outlet pierced by the radicle would be much more rapid, but the testa being once pierced by the radicle, opens the way to easy destruction of the contents, by giving access to the spores of microscopic fungi, and the produce is never of first class quality.

Probably the most important of the underlying principles of the different methods of "Fermentation" is that which creates a certain amount of absorption through the testa or skin of the bean, which is secured by most methods. A certain amount of heat is required, some make use of sun heat, while others use the heat of fermentation induced in various ways, while others again use both. Small quantities are best fermented by being put into a tin vessel and then exposed to the sun to start the fermentation. Although the methods to obtain good results, are known by practice to every intelligent Cacao planter, yet formerly there was much guessing at the quantity and quality of material used to obtain these results. Now that we have Professor Harrison's analyses and actually know what the beans contain before and after fermentation, it will be possible after some further trial and experiment to decide which process of fermentation produces the best results.

In Aublet's "*Plantes de la Guiane*" I find the process of fermenting the produce of *Theobroma Guianensis, Aubl.*, given in the following words :—

Pour conserver l'amande du Cacao, lorsque le fruit est dans sa parfaite maturité, l'on rassemble auprès d'une cuve la récolte qu'on en a faite ; on coupe par le travers la capsule en deux portions pour en tirer toute la substance, et les amandes qu'elle contient, qu'on verse ensemble dans le cuve. Cette substance sous vingt-quatre heures entre en fermentation, ensuite se liquéfie et devient vineuse. On laisse les amandes dans cette liqueur jusqu'à ce que leur membrane ait bruni et qu'on reconnoisse que leur germe soit mort ; car la bonté du chocolat dépend en partie de la maturité du fruit et du degré de fermentation que l'amande a éprouvée par ce procédé. Les amandes se séparent avec facilité de la substance qui les enveloppait, et sechant bientôt. La liqueur vineuse est un peu acide et banne à boire ; mise dans un alambic et distillée, elle donne un esprit ardent, enflammable et d'un bon goût.

Freely translated this will read :—

To preserve the kernel of the Cacao, the fruit, when ripe, is cut in halves, and the kernels it contains are thrown together into a vat. The substance surrounding the kernels ferments within twenty-four hours, then liquefies, and becomes sour. The kernels are left in this liquor until the membranes have become brown, and the germ is known to be dead,

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for the quality of chocolat depends on the maturity of the fruit and on the degree of fermentation it has undergone. The kernels or nibs separate easily from the substance surrounding them and dry by degrees. The sour liquor is acid, but good to drink, and an ardent spirit can be distilled from it which is highly inflammable, and of a nice taste.

This shows that the practice of fermentation was known long years ago and that this species of Cacao (probably a different plant from our Theobroma Cacao,) was used for producing chocolate. Aublet's work was published in 1775 or 125 years ago. It is curious to compare the conclusion come to by the late Dr. Chittenden (*viz.*) "stewing in its own juice," with the sentence:—"The kernels are left in this liquor until the membranes have become brown," and to note their similarity, and also my remarks as to the death of the germ or the destruction of vitality within the seed, both of which were conclusions arrived at previous to finding Aublet's description of the process. It has been said by some that we "cannot add anything to the chemistry of Cacao." The thorough enquiry into the subject by Professor Harrison has however shewn us the changes that take place during fermentation, and careful experiment will possibly show *the exact temperature* required for the proper fermentation of the bean. I am inclined to think from the few experiments I have personally carried out that the heat which occurs during fermentation is not so necessary for a proper preparation as is generally believed. When ascertaining the weight of fresh pulp surrounding the beans, it occurred to me to place the "skinned kernels" and the pulp that had been removed from them together and to allow them to ferment. These were placed in a confined space, and allowed to stand 3 days or 72 hours, and the temperature was only that of the outside air or a mean of 80° Fah. Fermentation had taken place and the smell and taste of the liquor instead of being sour, was sweet and agreeable, resembling very much the smell of the "wort" when the brewing of ale is in progress, shewing plainly that *diastase* was present, probably produced by the alteration of the albumenoid substances contained in the pulp, or in the bean, or by the pulp and bean conjointly. The office of *diastase* appears to be to effect the conversion of a portion of the starch of the bean into dextrin, and thus to render it soluble, for we know that the same process takes place in the malting of grain, but the process here differs, from the fact that germination is not required to take place but should be prevented. Malt differs from barley insomuch as it contains more dextrin and soluble substances, but rather less starch, cellular matter, and insoluble albumenoids and a smaller proportion of inorganic constituents; and that there is a similar difference between the *unfermented* Cacao bean and the *fermented* one, admits of no doubt.

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The kernels of the beans which were placed with the pulp had assumed the much desired colour (the cinnamon red) which it is the ambition of the planter to produce, and it will be observed that they did this in the short space of 72 hours or 3 days, when it is probable that if they had been fermented with the skin on, it would have taken three or four times as long to have secured the same colour to the kernel of the bean and appears to demonstrate what constituent it is that produces the colour. The bean however when thus treated is liable to mould very rapidly, but the break and colour is all that could be desired in a first-class Cacao. It would hardly be practicable to treat Cacao on the same lines in large quantities, neither perhaps would it be desirable, but the experiment adds something to our knowledge of the process which has so long been followed.

The skin or testa of the bean, after having allowed the changes caused by fermentation to happen to the kernel through its membranous texture, appears to be finally useful in preventing the ingress of the microscopic fungi or mould, which would destroy the interior parts, the toughened covering acting as an efficient preservative of the interior, once it is properly cured. If not properly dried, the testa or skin cracks, and the interior becomes mouldy and rapidly loses quality.

The temperature maintained in the sweating boxes has been variously stated. In the prize Essays it was given as 100° Fah, rising to 118° and 120° which from frequent personal readings under different conditions I believe to be the average heat which can safely be developed. In very large fermenting chambers, the heat rises somewhat higher, but there is danger in allowing it to rise above 140°, as the character of the produce is sure to suffer. Frequent turnings have to be undertaken to prevent too high a rise of temperature.

In reality the practice of fermenting Cacao is a simple one when conducted on the older methods, but it is time that more scientific method of working were brought into use, with a view of introducing and maintaining a higher standard of quality for Trinidad Cacao. Progress has been made it is true during the past decade, but it should go on at a faster rate.

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CHAPTER VIII.

Preparation of the Bean.

WASHING.

CACAO must be washed immediately after fermentation, or not at all. The pulp cannot be removed except by the aid of this process and even after the decomposition set up by fermentation, the pulp is hard to remove. Ceylon planters appear to have adopted the washing process of preparing Cacao as being cleaner and better than the method which generally obtains in Trinidad, and I learn that the practice is now being followed in German West-Africa where large plantations are being made. The prices obtained by Ceylon produce is a guarantee that it is of first class quality, and prices compare very favourably with those obtained by the best Trinidad samples. Brokers in London however advise Trinidad growers not to wash their Cacao, the chief argument being that what is gained in price, is lost in weight, and vice-versa. Anyway, washing does not find favour with the Trinidad producer, although a few who have tried the method have not been wholly unsuccessful, but they never succeed in making an article which could be fairly compared in appearance with Ceylon samples.

The late Mr. E. Lange in Agricultural Record March, 1891, clearly proved that the extra trouble was not compensated for by the price obtained; still, the tenour of his article appeared to favour the washed product. Mr. Lange stated in his article that Messrs. Wilson Smithett & Co. *advised him that it was not advisable to imitate Ceylon Cacao because the principle value of that class of Cacao resided in its pale cinnamon break, which whether due to the soil or a different variety of Cacao, Trinidad planters could not imitate.*

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Dr. Morris appears to favour the view that the kind of Cacao mostly grown in Ceylon is of the Criollo type, and after a long study of the question, I am led to fully concur in this view. The late Dr. Trimen in his report for 1890 gives the remarks made "by a large grower who has great opportunities for "observation that the *Forastero* varieties which he chiefly "cultivates, appear to be gradually changing their characters "and becoming more like the 'old Ceylon Red,' the seeds losing "their dark colour on section and becoming pale or nearly white," which clearly indicates that cross breeding is now taking place freely in Ceylon. In Grenada I believe such a change to be common and clearly apparent (*i.e.*) the character of Forastero as imported from Trinidad soon disappears owing to the greater predominance of other types.

If the superiority of Ceylon Cacao is due to a difference in the variety of plant producing it, it is certainly no use to attempt by washing to imitate it. I am fairly sure however that it is really a difference of kind which decides the difference in quality rather than any method of preparation. There are differences due to soil and situation which should by no means be overlooked, but I am in no way sure that the common practice of attributing nearly all differences of quality, to a difference in soil and climate, is a safe one, as it is not known to have more than a minor effect with other things. Plant the Jargonelle pear, or the Ribston pippin apple where you will, you can never make anything else of them but Ribston pippins and Jargonelles, and why the soil should be credited with making differences with Cacao as broad as would convert the apple into a crab, and the pear into a quince, I fail to understand, but would rather believe that the quality lies entirely in the intrinsic value of the special kind cultivated.

DRYING AND POLISHING.

In Trinidad the general method adopted for drying Cacao is by exposure to the sun on large wooden floors or trays which can be rapidly covered when rain is about to fall, either by running in the trays under a fixed roof, or having a movable roof over a fixed floor. The latter is by far the most common form of drying-house used in Trinidad, though both systems are in use, separate and combined.

The houses are erected of wood, the floor being made large or small according to the size of the estate. The general run of floors are about 40 to 50 feet long by 18 to 20 feet in width. The sliding roofs are made extremely light, placed on wheels and are covered with either plain or corrugated galvanized iron.

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The roof is divided in the centre, and when the floor is exposed, each half is received by a frame-work contrived at each end of the house. The central portion under the flooring may be used for two sets of trays, one on each side, which are made to run on wheels or light iron rails, and so arranged as to be run out on frame-work at right angles to the main frame-work of the building.

In these trays the Cacao is exposed to the sun, after being sufficiently fermented, but in the middle of the day it is the practice, if very clear, to close the house for an hour or two, to prevent the excess of heat from blistering the Cacao. The layer of beans is spread about 3 or 4 inches thick over the floor, and is turned frequently during the time it is exposed to the sun.

The length of time taken up in drying depends in a great measure upon the way in which it has fermented. Cacao properly fermented dries much quicker than the partially fermented bean, and of course much depends upon the weather. In rainy seasons, when there is much damp present, there is considerable difficulty in making a good sample of Cacao; in fact, Cacao at such times is often greatly depreciated in value, and sometimes becomes a total loss. Owing to this fact, it is estimated that a very large sum would be annually saved to the country, if more satisfactory methods of artificial drying were generally instituted. The Central Agricultural Board of Trinidad offered a prize of $200 for the best Cacao drying apparatus at their Exhibition in October, 1890. The full prize was not awarded but an honorarium of $40 each was awarded to three designs which were of considerable merit.

The first was simply the adoption of the method of heating by hot water, to the ordinary Cacao house. The second was a telescopic drying apparatus adapted for either dry or wet weather, and the third was a dryer having the means of keeping the beans constantly stirred, which appeared promising.

Several sets of apparatus on the first principle have been erected and found to work satisfactory but I have not learnt that anything has ever been done in the way of advancing the usefulness of the second design. The third design was erected on a large scale, but it was found that the moring of a large weight of beans, crushed the cuticle, and the idea has been abandoned.

Sir William Robinson in his pamphlet (1890) gave an account of the Ceylon drying house as furnished by the late Dr. Trimen, it is as follows:—

"The house is about twice as long as broad, built of brick, and is provided with double doors, but with the exception of the openings for the ingress and egress of the hot air, is hermetically sealed. The interior

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is fitted with a number of upright frames into which slide, one above the other, the trays upon which the beans are spread; these should be made of narrow pieces of split bamboo, not of wire or coirnetting. The heating apparatus is outside in contact with one end of the building, and consists of a large stove standing in a short tunnel which opens into the house. At the other end of the building, also outside, is a powerful fan, fitted in another short tunnel; this is worked by hand (three or four Coolies needed), and by its rapid revolutions draws the air through the house. By passing over and rouud the stove the air is dried and heated; that which passes out is hot and damp. The flue of the stove passes under the floor of the house and contributes to warm it. A drying house of this sort is very simple and its *cost only about 120 rupees;* it does its work perfectly, and *nothing more elaborate or costly is required.*

It is found desirable here to dry Cacao as slowly as possible provided the risk of mould be avoided. This appears in the interior of the beans in twelve hours and on their outside in about twenty-four in wet weather if they are left cold, but by passing them rapidly through the hot air house, so as to have them hot when taken out, it is found that they will remain for a night or so in the store without injury.

As the annual average number of rainy days in Ceylon is from 80 in dry districts, to 328 in the wet, and Cocoa is grown only in the moist regions of the Island we may assume that at least four-fifths of the Cocoa exported from that Colony is dried artificially. The rainfall in the best Cocoa Districts of Trinidad appears to average between 80 and 100 inches. The total yield as before stated is 125,000 cwt. representing an enormous crop and an immense number of people dependent upon it. *Yet there are not half a dozen artificial drying houses, if as many, in the whole Island.*"

The method appears to be a very simple one, but the amount of labour needed ("three or four coolies") appears to be large when compared with that required for the ordinary Trinidad methods.

It will be observed from the above that the Ceylon planter found it desirable to dry Cacao as "slowly as possible, provided the risk of mould be avoided." This opinion has been long held by many Trinidad planters, and some are of opinion that no drying apparatus which will shorten the time of the operation in any great degree, will secure general adoption, as it is to be feared that the quality of the Cacao will suffer if too quickly dried. However, if it can be proved that the quality of the produce does not suffer by quick drying, the method will undoubtedly be of the greatest service to the Cacao planter, and experiments in this direction tend to show that it does not really suffer, but is rather improved by quick drying.

However this may be, it is certain that so much loss does not occur during bad weather as formerly, owing to the adoption of various systems of artificial drying.

Machines which are made to revolve as a cylinder, have not been a success, as it has been found that a heavy weight of moving Cacao breaks the outer shell of the beans and therefore

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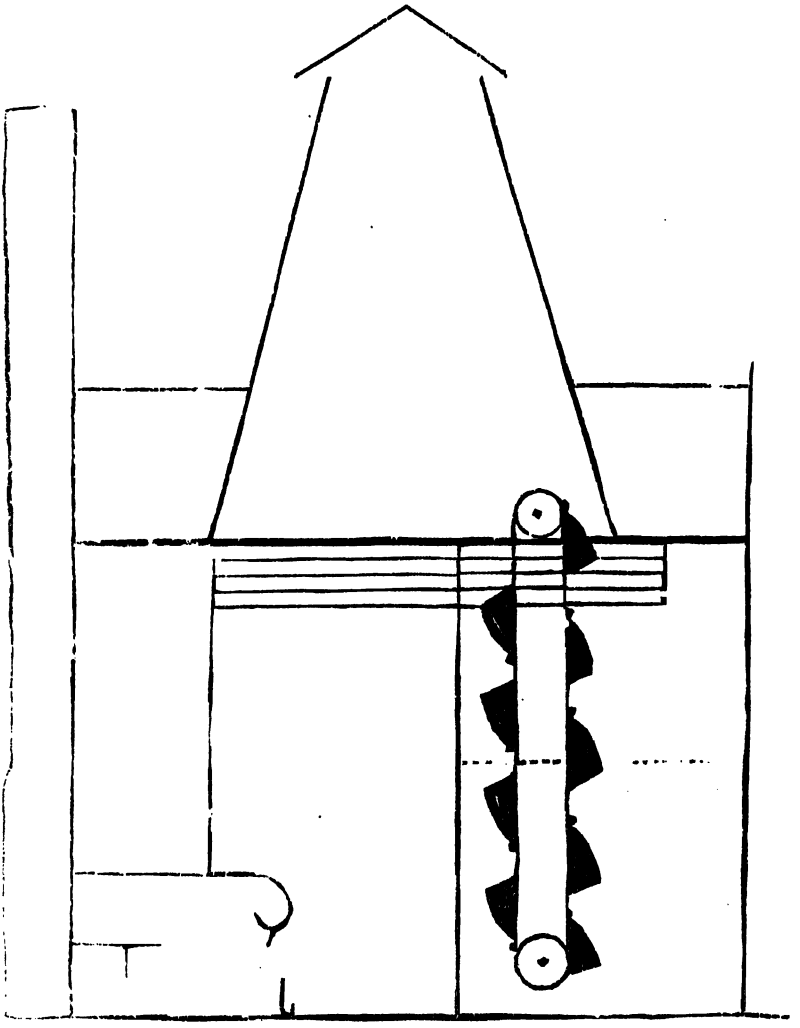

Drying House.

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damages the sample. One of the most effective and simple systems of which I have information is that having a circular floor pierced with numerous small holes, under which are placed rows of small pipes heated by low pressure steam. From the floor centre an upright shaft ascends which is driven slowly by hand or other power. This shaft carries two or more bars or booms running horizontally an inch or so from the floor. These bars carry small ploughs, or turning shears and brushes which slide upon the floor and keep the beans in motion and allow the drying to proceed rapidly, a chimney or funnel allowing vapour to escape. The upper part of the shaft by a simple attachment drives an exhaust fan. The heating apparatus need not be of an expensive character, as it could be made locally in most places under intelligent direction, once a plan of the building, boiler and tubes is furnished, but it is a necessity to have a circular building. This may be built either of concrete, brick or wood throughout, but concrete is certainly preferable for the basement, and wood for the upper story. It is estimated that a building and apparatus to dry 10 bags in the 36 hours will cost £200, but to dry 50 bags per day the apparatus would cost much less in proportion.

During the drying process Cacao has to be frequently turned, but it appears to dry better if kept in 3 or 4 inch layers than if spread more thinly over the surface of the drying floors.

In curing Cacao some Trinidad managers make use of red-earth for the purpose of getting rid of the mucilage of the bean in a more expeditious and handy manner, and this method appears to be also in use in Venezuela. The process is described as follows :—

We now come to the picking and drying of Cocoa (Cojida y seca). Without going into details it would appear that in Venezuela the greatest care is taken in the matter of picking. The ground on which the pods are to be placed, after having been cut from the tree by the pruner (desjarretadera) is carefully prepared by the spreading of plantain leaves on it in proportion to the picking. Here women are placed who cut the pod in order to get out the beans. The pods that are overripe or black or picked by birds are separated, so that at this early stage there is a careful classification of the fruit. When the Cocoa is taken from the pod or shelled, it is measured in baskets in order that the result of the picking may be known. It is then conveyed to the curing-house. If the picking is one of several consecutive days it is dealt with as soon as possible, for it is not advisable to accumulate the pickings of more than two or three days. It is preferable to deal with one day's picking on the following day when the grains are very thinly spread in the curing place in order that the damp and clammy (humido y enjuto) mucilage may be dried up. Great care is now taken not to crack the kernel. It is raked with a wooden rake, and when it is being bagged for the curing-house a wooden shovel is used.

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It is absolutely necessary that on the *first day* of exposure the Cocoa (beans) should have the full benefit of the sun. In the afternoon it is collected, heaped up in a dry room and sheltered with sheets of wrapping cloth during the night. On the day following it is dried in the morning and spread about in small lots. Then the operators, with a fine sieve, sift over it a very small quantity of red earth, which is well prepared and pounded in a mortar in anticipation. This earth must be thoroughly pulverised and perfectly dry. An object is gained by this operation, viz., to give to the Cocoa colour and gloss. Failing coloured earth, brick dust or red ochre is occasionally used, but red earth gives the better colour and is more approved by the exporters. When this operation has been finished the curing place is dried and left wide open in order that the Cocoa may be well under the influence of the sun. It is given only *six* hours on this day, when it is gathered up, placed in a dry room and well sheltered, in order that it may go through the process of curing for the day and the whole of the night. On the third day it is dried in the sun *four* hours. It is again re-gathered warm into a heap, and it is sheltered in the room the rest of that day and the whole night. On the fourth day the same process is repeated.

In case any dampness is observed amongst the beans they are exposed to the sun during the morning of the fifth day. But they must not be exposed to too great a heat because this would dry them too much, and besides the kernel might crack and the weight might be diminished. After this stage has been reached the Cocoa is placed in wooden trays (Bateas) and ventilated. The dry husks and useless grains are got rid of, and it is then thoroughly clean and fit to send to the market.

COLOURING AND DANCING.

It appears that in Venezuela the practice of using dry-earth is, first, for the absorption of the mucilaginous portions of the covering of the beans, secondly, to give the bean "colour" and 3rdly in some measure to prevent or minimize the growth of Fungi, or "mildew."

In Trinidad various mixtures are used for colouring purposes and for bringing out the polished appearance of the Cacao; among them may be mentioned starch, red ochre, *roucou* or annatto, and red earth or clay. The red clay of *San Antonio* Estate, Trinidad, is described by the late J. J. Bowrey, Government Analyst, Jamaica, as "*a very fine ferruginous clay free from organic matter*," and is said to answer the purpose admirably. Dressing or colouring of Cacao is however more practised by merchants who purchase from the small growers than by the well-to-do planter, as by this means they are able to put an even appearance on samples of different qualities; but Cacao of finest quality and appearance can be made *without the addition of any single particle of extraneous matter*, if the methods of the best estates are adopted.

In damp weather the partially dried bean is extremely liable to be attacked by numerous microscopic fungi or moulds, and if these are allowed to continue their growth undisturbed

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the coating of the bean is pierced and its contents spoiled. Various measures are adopted in bad weather to disturb the growth of the mildew, and of these none is more familiar than the process called "Dancing." The Cacao is collected in heaps and the labourers are employed to tread the heap with their naked feet. The friction caused by the treading removes the mildew from the outside of the beans and polishes them at the same time. Where "dancing" is not convenient "hand rubbing" is resorted to for the same purpose.

The process of drying is always continued until the Cacao is thoroughly dry, but only an experienced hand can tell when this point is reached.

If well cured it should have the outer skin separating from the cinnamon colored interior. The latter should be firm, bright, and break easily on pressure with the fingers.

It may be added that a plump bean of a light chocolate, or what is known as a "cinnamon" colour, is a mark of the highest quality of Cacao, when combined with what is known as "a good break." Samples of darker colour have of late years found favour in some markets for special purposes, but the highest flavour certainly remains with the light colored and fermented bean which has a good break.

It would appear to be held by some that heat is especially necessary to harden the interior of the bean, and that to obtain this it is found necessary to heap the beans, so as to make them undergo a second and third fermentation at intervals during the drying process, and it is contended that without this the bean will often refuse to assume that plump appearance which is held in such high estimation by buyers.

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PART III.

CHAPTER IX.

Botany and Nomenclature of Cacao with Description of Typical Forms, &c., &c.

HE name which Linnæus conferred upon this plant is derived from the Greek *Theos* (god) and *Broma* food, or "Food for the gods."

There are several species of the genus, which is native of tropical regions extending from Mexico to Brazil, and among the known species are the following:—*Theobroma bicolor*, *T. guianensis*, *T. sylvestris*, *T. ovatifolia*, *T. angustifolia*, *T. pentagona*, all said to be distinct from our cultivated *Theobroma cacao*, L., and its varieties which is the kind from which the major quantity of the marketable product known as Cacao or "Cocoa" is derived.

The Mexicans give to *Theobroma cacao* the name of Cacao-quahuitl, which has been in a great measure retained in the word chocolate. Trees of *Theobroma cacao* grow in some places to forty feet in height, the writer having seen them of this size in the province of Veragua in 1885, but the usual height of the Trinidad tree averages about fifteen or twenty feet, the lateral diameters of its branches being about the same measurement. In Grenada, Tobago and St. Vincent the trees are generally of smaller size.

The Botanical characters of the genus are given in Grisebach's Flora of the British West Indies, p. 91, as follows:—

ORDER STERCULIACEÆ—TRIBE BUETTNERIEÆ.

Calyx 5 partite, colored. Petals 5: limb cucullate, with a terminal, spathulate appendage. Column 10-fid: fertile lobes bi-antheriferous: anthers bilocular. Style 5-fid. Fruit baccate, 5-celled: cells pulpy, polyspermous. Embryo exalbuminous: cotyledons fleshy, corrugate. Trees; leaves entire; pe[illegible]s fascicled or solitary, lateral.

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The description of our species is given in the same work in similar terms :—

T. Cacao, L.—Leaves oblong, acuminate glabrous, quite entire; flowers fascicled; pericarp ovid-oblong 10 cosiate. Calyx rose-colored; segments l anceolate, acuminate, exceeding the yellowish corolla; pericarp yellow or reddish, leathery 6 to 8 inches long. Habitat, Trinidad—De Schach. Naturalized in Jamaica! Dist. St. Lucia! Anderson. [Guiana and Brazil!]

The various names under which the varieties of this tree *Theobroma cacao*) are known do not constitute species, but must be merely considered as *varieties* of one original species. These varieties probably owe their origin to seed variation and cross breeding, together with the influence of soil and climate, but to enumerate the whole of their names would serve no useful purpose.

Dr. Morris's classification* was based upon the nomenclature of some of the best estates in Trinidad. Some modification of this nomenclature is now however desirable. It must be admitted however that the local nomenclature of various districts differs much, one with another, and it would therefore be a hopeless task to attempt to reconcile these names. It is also patent to the observer that there are certain characters of cacao more strongly marked than others, as exemplified in the varieties known as Criollo, Forastero and Calabacillo, though Dr. Morris contents himself with forming them into two great classes, "Criollo and Forastero," and he gives Calabacillo as a variety only of Forastero.

In the first edition I divided these various kinds into three classes placing Criollo as Class I., Forastero as Class II., and Calabacillo as Class III., being the inferior type of the species.

CLASS I. CRIOLLO.—OR FINE THIN-SKINNED.

1. Var. *a*, Amarillo.
2. ,, *b*. Colorado.

CLASS II. FORASTERO.—OR THICK-SKINNED CACAO.

3. Var. *a*. Cundeamor verugosa amarillo.
4. ,, *b*. ,, ,, colorado.
5. ,, *c*. Ordinary amarillo.
6. ,, *d*. ,, colorado.
7. ,, *e*. Amelonado amarillo.
8. ,, *f*. ,, colorado.

CLASS III. CALABACILLO.—OR SMALL-PODDED, THICK, SMOOTH-SKINNED, FLAT-BEANED.

9. Var. *a*. Amarillo.
10. ,, *b*. Colorado.

* *No. 1, Yellow Creole; No 2, Red Creole. Nos 3 and 4, Cundeamor, is derived from the Spanish name of the "Cerasee" (Momordica Charantia) which possesses a peculiar warted appearance. Thus the name means Momordica-shaped, rough red or yellow cacao Nos 7 and 8 are Amelonado or melon-shaped, red and yellow cacao. Calabacillo, calabash-shaped cacao, red and yellow.*

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After the lapse of some years I still see no necessity to revise the list.

Dr. Morris in (Cacao and how to cure it 1882)* made two classes only, placing Calabacillo with Forastero. I retain the original classification because it appears to me to cover well all the various types which are present. Calabacillo is certainly as far removed from Forastero, as Forastero is from Criollo, as seen in Plantations of the present day, when every intermediate form from Criollo down to Calabacillo can be seen linking the whole in one continuous chain of varieties. To properly classify Cacao, we must first know what the originals were like, and it is clear that at the present time, it is hard to decide exactly what were the forms assumed by the older types of Cacao fruit. There is an apparent consensus of opinion however which points to the thin skined and bottle necked variety, as the original Criollo,† and this is quite confirmed by the Criollo being discovered in the virgin Forest of an uncultivated part of Trinidad. Criollo has either yellow or red pods (red or yellow coloring of the pod affects the interior but little and the same quality of bean may be formed under both colours, and the seeds when cut, show *a white or nearly colourless interior*. This character is also possessed by Java and Ceylon Cacao—and by the Criollo of Central America, and also by the produce of *Theobroma pentagona*. (Figs. x, y, z.)

Forastero Cacao of the best class also shews a light coloured interior but slightly tinged with purple, but this increases until in Calabacillo we have beans most highly coloured.

Venezuelan Cacao from some of the finest Estates, such as Ocumare and others can readily be distinguished by the lightness of the colour of the interior of the bean and by the shape of the bean although to all outside appearance, the pods belong to the general type of Forastero. On Trinidad Estates, which have introduced certain strains of Cacao from the Mainland, we find what I consider is the finest class of Forastero Cacao. In ordinary Cacao, pods may be found illustrating the passage, by almost imperceptible differences, from the Criollo on the one

* "Cacao, How to grow and how to cure it." D. Morris (Jamaica, 1882)

† Criollo—Spanish for Creole.

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FIG. X.
Calabacillo.

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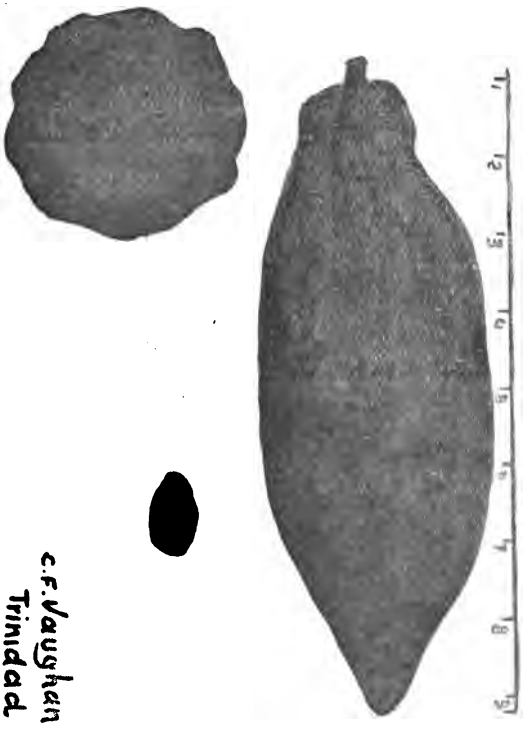

FIG. Y.
Criollo.

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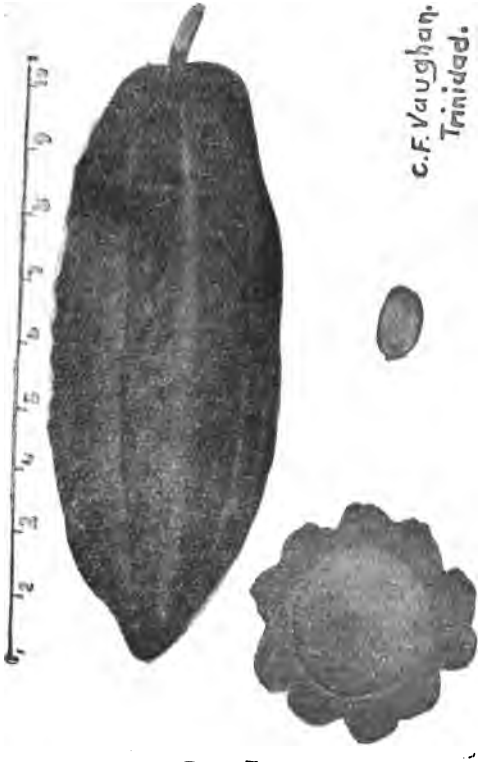

FIG, Z.

Forastero.

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hand, to the Calabacillo on the other. In a paper read before the 1st West Indian Conference 1899, held at Barbadoes I stated that :—

"The only attempt at the improvement of the quality of Cacao is that which has been made by the selection of seed by its external character (in the pod) and the import of seed from other countries. The result is that to-day although the remains of the original types are clearly apparent, it is also clear that, though bringing good prices the Cacao as now grown is as a whole nothing less and nothing more than an aggregation of cross breed varieties.* Some few might attempt to do so, but I think a wise planter would hesitate if he was asked to show where Criollo ended and Forastero began, or where Forastero ended and Calabacillo began. The fact is that the Cacao of the West Indies is nothing more nor less than a mixture of various strains, which again vary in and among themselves in no certain direction, and among which the characters of the ancient types appear more or less developed according to the character of their surroundings and the numerous influences which have been brought to bear upon them. The quality of the Cacao produced from these strains (or types) is variable, some selling for good prices, while other brands are decidedly inferior. The character of the leaves, the form of growth, the colour and form of the fruit, the size, shape and colour of the interior of the bean are all variable to a degree, and few trees can be found which are the exact counterpart one of the other, either in their produce or the vegetative characters.

The discovery (by the author in 1898) that Cacao can easily be grafted by approach now puts into the hands of the planter means whereby he can secure a crop of one particular kind or kinds at will, and further it will enable him to make samples of a character formerly impossible. It will also enable him to grow such types as the Criollo or any weak grower upon the vigorous growing varieties of the Calabacillo type.

When grown from seed the selection should only be made after due examination of the interior of the bean, as the quality of the finished article can generally be determined by this means. The trees selected for seed bearers should be vigorous, healthy, of good form and the blossoms should be efficiently protected from Cross fertilization, or if deemed expedient the flowers themselves may be artificially fertilized. It would then be seen that the produce could be made to come true to a very high percentage, and once plantations of a single type could be brought into existence, then superiority would be so obvious that no further persuasion would be required to have the method generally adopted, as it would be seen to be the most profitable practice which could be pursued. Fields would then be arranged so as to produce a sample of one certain quality, showing no variation in the size and form of bean or the quality of its interior. It would be possible to have plantations on which not a single Red pod could be found, and others on which not a single yellow one could be seen."

How easily this result could be obtained by grafting is readily to be seen, and although perhaps slightly more lengthy and expensive, it is I think a preferable mode of propagation, to that of raising from seed; more expensive it is true, but in the

* It has been found that Forastero in Ceylon gives rise to forms representing every type of Cacao grown. (Martin Report to Planters' Association, 1892.)

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long run I am sure would pay very handsomely. There are excellent kinds already on Trinidad fields and the best of these should be propagated by grafting and grown under local names, such as Gordon's "Excelsior Cacao," Leotaud's "Promise Cacao," Agostini's "Surprise Cacao," De Gannes "Best of all Cacao"—which would be infinitely preferable to retaining names such as Criollo, Forastero, by which the various kinds can only be very indefinitely and sometimes very inaccurately identified.

The finest cacao is by general consent admitted to be produced by the Criollo, and this is assumed to be identical or similar in character to that called the Caracas variety. I think however there is considerable doubt if this idea is correct. In the Consular Report on the agricultural condition of Columbia, Consul Dickson mentions that "*the variety chiefly grown in Columbia is different to that of Venezuela, which produces Caracas cacao, the pods being much larger, and containing a greater number of beans, but as the number of pods produced by a tree is greater, it is probable that on the whole the Venezuelan variety is the more productive of the two. The quality of Columbian cacao is little, if at all, inferior to that of the Venezuelan, but it is little known in commerce, as only an insignificant amount is exported, the supply scarcely satisfying the demand of the country.*"

What this variety may be, we have no means of correctly ascertaining, but the comparison with the Caracas variety indicates that it is very near to, if not synonymous with our Forastero, and it is to be noted that such a variety would also be "Forastero" or foreign to the Caracas people.

The late Dr. Trimen of Ceylon, in his Annual Report for 1890, fell into the error of interpreting the word "Criollo" or Creole as being synonymous with "wild."

It is well known, however, that the word is never used in this sense in the West Indies, the true interpretation of the word "Creole" being—one born in a country or one belonging to a country. With European Anglicans the word "Creole" is generally supposed to have reference to a mixture of races, but it is not used in that sense in the West Indies or Jamaica.

For instance, a child born of white parents in any West Indian Island, or even on the mainland of Central and South America, is a "Creole," and just as much so, as a black or coloured child would be. In fact, "Creole" should be translated as "native" and not "wild" or Coloured; a black or coloured child being just as much a Creole, as a white one or a mulatto and *vice versa*.

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It is important that the sense in which the word "Creole" is used should be fully understood as we have "Criollo" as our first variety of Cacao. (Criollo is Spanish for Creole.)

If we interpret the words Criollo Cacao as Native Cacao, and Forastero as Foreign Cacao, and Calabash Cacao as Calabacillo Cacao, we should have had a better definition of terms, and prevent further misapplication of the word "Criollo." Calabacillo is so named from the resemblance of the pods to one of the forms of the fruit of the Calabash tree (*crecentia cujete, L.*)

The late Dr. Trimen in Annual Report Ceylon, 1890, remarks that these names appear to have had their origin in Trinidad, and doubted whether Criollo was "*ever really a native plant there*" (Trinidad.)

The misunderstanding of the word Criollo or "Creole" probably led him to this conclusion, for it could not be native or "Creole" if imported into Trinidad unless its name was imported from South America with it, and if so, it should be known as South American Criollo or S. American Native Cacao, and not simply Criollo. The word "Trinitario"* is applied on the "Spanish Main" to the Cacao known as Forastero in Trinidad and they term it so in contradistinction to their own Criollo. A plant of Trinidad would clearly be Forastero or Foreign in Venezuela, and therefore, their "Trinitario" being a foreign Cacao and supposed to have its origin in Trinidad, would properly be the Criollo of Trinidad, if the word is used in the correct sense.

It may be possible, however, that Criollo Cacao is native of both countries. The balance of probability appears to be, that its origin can be traced to South America as indicated by Dr. Trimen.

In Nicaragua the plantations appeared to the author to consist principally of the Criollo type. The interior of the Nicaraguan bean is commonly white, but where the trees have been planted close to the imported Forastero, there is a most perceptible increase in the colour of the beans, and of this I can bear personal evidence.

Dr. Trimen repudiated the authenticity of the word Criollo, attached to plants sent him from Trinidad, and calls them Forastero on account of their being dissimilar to "the old Ceylon

* Dr. Chittenden in Agricultural Record, Vol. II., p. 107.

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Red Cacao, also called Caracas." (Ceylon Report, 1890.) He allows however that the Forastero sent from Trinidad to Ceylon, is gradually changing character and "becoming more like the "old Ceylon Red."

It is probable that Dr. Trimen was quite correct in repudiating the name, for if the "white seeded" wild variety is the ancient Criollo; then many of our present day forms are intermediate between that and Typical Forastero. That a change of character from distinct forms is possible is admitted, and moreover our best botanists do not find sufficient distinctive characters (notwithstanding the differences in the form, size and colour of fruit, leaf and tree) to make more than *one species of all our cultivated varieties;* which as Dr. Trimen truly says, probably trace their origin to a common wild parent.

Dr. de Verteuil, now Sir L. A. A. De Verteuil, K.C.M.G., tells us in his work on Trinidad 1884 p. 242—"That from its first settlement Trinidad exported Cacao, and *that* Cacao soon gained a reputation on account of its delicious aroma. According to Gumilla it was superior to that of Caracas and other places, so much so that the crops were bought and paid for beforehand."

"In the year 1727 however, a terrible epidemic spread in the Cacao plantation" and complete ruin followed.

The nature of this epidemic is indicated, for Sir Louis states "the trees were apparently healthy and vigorous, the "flowering abundant, giving fruits but none of them came to "maturity as the young pods dried up before full growth."

It is of course impossible to decide exactly what this disease really was, but the presence on the plantations of to-day of a disease* which might be similarly described, leads to the inference that it was of fungus origin and similar if not identical with that recently identified.

"Thirty years later, some Aragonese Capuchin Fathers "were successful in their attempt to revive the culture of Cacao "in the Island. They imported from the continent a new "species (variety J. H. H.) the Forastero Cacao which, though "giving a produce of inferior quality was nevertheless promptly "propagated as being hardier, that is the Cacao at present "cultivated in the Island."

The characteristics of Criollo cacao are the thinness of the shell of the pod its rounded beans and pale colour of the interior of the bean on section. The leaves of the tree are small when

* Discussed in a later chapter.

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compared with the Forastero varieties, and the tree itself is not nearly so sturdy and thriving, and does not produce such regular and abundant crops as the Forastero and Calabacillo varieties. The skin of the bean is thinner, and the interior has but a small proportion of that bitter flavour which is characteristic of the unfermented bean of Forastero and especially that of Calabacillo.

The flattest beans are those produced by pods of the Calabacillo type. The beans of Forastero are intermediate between these and the rounded form of the Criollo, which are often slightly pointed. (Fig. A.)

The above sketch of beans of three typical varieties show the difference in form which occurs, but there will be found intermediate forms hardly reconcilable with any of the figures so that these must be taken merely as the type forms of the varieties mentioned. (Fig. B.)

Figures 4, 5 and 6, represent respectively beans of Theobroma bicolor, Nicaraguan Creole, and the best or high priced variety of Venezuelan Cacao sometimes called "Caracas" Theobroma bicolor has fruited for several years in Trinidad, since its introduction in 1893, but the beans do not enter as commercial Cacao. The Nicaraguan bean is the largest Cacao bean I have seen, and is of the finest quality, only to be approached by the finest flavoured Criollo, or "Caracas."

There are rounded beans* to be found in almost every pod towards its extremities, but the proportion of rounded beans in Calabacillo is very small indeed, and the yield of this form of bean increases only as the character of the pods approaches the Criollo type. Calabacillo, or that class which gives small, rounded and smooth pods and flat beans, having a bitter taste, is the lowest type of Cacao that is grown, and requires the greatest amount of skill during treatment to bring it into marketable form, the process of fermenting it, taking more than double the time required for Criollo. The tree however is the strongest grower and the hardiest of all the varieties, and will thrive on poorer lands and on lands on which it would be impossible to grow the finer kinds.

In the best forms of Venezuelan and Trinidad Cacao, the beans are characterised by a peculiar prominence on their sides, (see Figs 2 and 6.)

Trees of the Forastero type are strong growers, and its varieties are therefore suitable for most lands in which cacao can reasonably be expected to thrive. It approaches the

* *The word "bean" is incorrect, but as it is the common form of expression among our cacao planters, it is used as being better understood than any other.*

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Calabacillo type by the Amelonado variety, both red and yellow, and certainly stands as a large intermediate and variable type between Criollo and Calabacillo. In general the Forastero has a thick skin. It approaches the Criollo in form, or runs into Criollo by its variety *Cundeamor verugosa*, red and yellow; but trees may be found bearing pods which are hardly to be distinguished from the Criollo on the one side and the Calabacillo on the other, thus showing the breadth of form covered.

The planter should ascertain the character of his land with as much accuracy as possible before deciding what variety of Cacao he will plant. If very poor he can rely on Calabacillo only, if moderately rich Forastero, but on rich and lasting ground the best types may be planted. If however the best types were grafted on the strong growing Calabacillo there would be more probability of succeeding in growing the best varieties on inferior as well as rich soils.

The generality of plantations in Trinidad contain trees so mixed in character that it is difficult to separate one kind from another, although it cannot be doubted that it would pay well for any extra trouble, if a system of planting each type in separate fields were adopted.

The contract system which prevails in Trinidad is probably more to blame for the mixed character of the fields than anything else. The contractor has perhaps in the first instance planted from seeds supplied to him presumably, all of one kind. In supplying first vacancies he uses the stronger and larger growing plants, and in places where the plant has refused to grow after planting twice or thrice, he will (rather than lose count of a tree) put in a plant of the strong-growing Calabacillo.

In length the leaves of Criollo type vary from 5 to 12 inches and from 2 to 4 inches in breadth. Some were recently examined over three feet in length. Forastero Cacao gives the largest leaves of all. For the sake of accuracy I have made special measurements of some growing in the Royal Botanic Gardens and find that they vary from 9 to 21 inches in length, and range from $2\frac{1}{2}$ to 6 inches in width.

The leaves of the Calabacillo type are shorter and wider in comparison with their length than either Criollo or Forastero.

It must be understood, however, that these measurements are taken from extreme forms, and that the nearer the trees approach other varieties, the nearer alike are the leaves.

Cacao is said to have been cultivated largely in Jamaica some two hundred years ago, but according to Long, in his History of Jamaica, the plantations were destroyed by a "blast."

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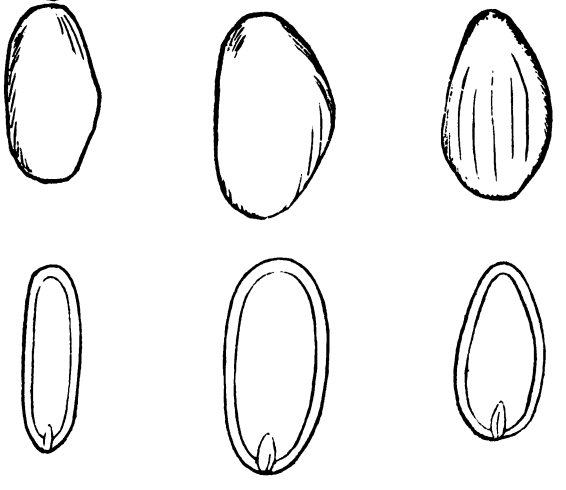
Fig. 1. Fig. 2. Fig. 3.



Calabacillo. *Forastero.* *Criollo.*

FIG. A.

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Fig. 4.

Theobroma Bicolor.

Fig. 5.

Nicaragua Creole.

Fig. 6

Caracas Cacao.

FIG. B.

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Dr. Morris mentions that in Trinidad also the trees were visited by a blast "sometime during the last century." He interprets the word "blast" as a "blow or hurricane," but the word in East Anglian brogue has another meaning. "Blast" is there synonymous with "blight," and this is confirmed by Walker's Dictionary as follows: (*to blast—to strike with some sudden plague*). Either interpretation would however fully account for the destruction of plantations, especially when taken in conjunction with the high rate of duties which was imposed on the article in England at about the same time. Whatever the cause, the cultivation of Cacao in Jamaica received a wonderful check, for in 1671 Long states there were as many as sixty-five walks in bearing; while in 1882 it was only grown in isolated instances until the value of the product was brought into notice by Dr. Morris when resident there as Director of Public Gardens and Plantations, when the cultivation largely increased. The introduction to Jamaica was probably effected by the Spaniards as the English only came into possession of that island in 1655, or sixteen years previous to the date mentioned. One species is mentioned by a writer (Martius) as having been found in Jamaica (*Theobroma sylvestris*) but accuracy of this would appear to need confirmation.

It is generally admitted that Theobroma Cacao is to be considered native of the Northern territories of South America; and the finding of plants in Virgin Forest in Trinidad, is strong evidence that it is a native of the Island, as well as the Mainland.

Spon's Encyclopædia gives *Theobroma angustifolia*, *T. bicolor*, *T. guyanensis*, *T. microcarpa*, *T. ovalifolia*, *T. speciosa*, *T. sylvestris* as producing commercial cacao, but we cannot learn upon what authority.

When travelling in Central America in 1885, I found *Theobroma bicolor*, Humboldt and Bonbland, indigenous in the provence of Veragua, United States of Columbia. It was known as "Tiger cacao," so named from the rank smell of the seeds. It is not in general use by the inhabitants, though it is said to be used in some manner by the Indians. It has also the name of "Indian chocolate" and "Wariba," the latter being the Indian name, and appears to suggest some connection with the "Wari" or wild hog, probably a peccary (*Dicotyles*) which is known to emit from a gland on the back a strong-smelling fluid.

From information gathered when in Nicaragua, and from observations made on tries introduced by the author to Trinidad,

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which have fruited, it is certain that Commercial Cacao of fine quality is produced by *Theobroma pentagona*, the beans of which are nearly double the size of the average Trinidad bean.

Figure 7. shows the pod of this species compared with a pod of Forastero.

Theobroma angustifolia, otherwise known as "Cacao Mono" or "Monkey Cacao" does not produce commercial Cacao as the beans are rank and ill flavoured. It has been introduced to Trinidad, but has not yet fruited.

The bean of *Theobroma guyanensis*, Willd, is said by Don to be white, and good eating when fresh. He also says that the seeds of T. bicolor are mixed with the seeds of the coommon Cacao.

Theobroma angustifolia were introduced to Trinidad at the same time as *T. bicolor*, and *T. pentagona* and all three are now well established, the two latter are now bearing (1899.)

Specimens of "wild Cacao" growing in the Gardens, and specimens sent me from Colombia belong to the *Genus Herrania*, a near ally of Theobroma.

It has been recently determined that the old Dutch Cacao of Ceylon is synonymous with the best and truest types of the Criollo of Trinidad, as a tree sent from Ceylon recently fruited in the Royal Botanic Gardens and enabled comparisons to be made, when they were found to correspond in every essential particular.

One of the Pachira's *P. insignis* is sometimes called wild Cacao—and is known in Trinidad as "Cacao Maron." It has been brought to me on more than one occasion as a "new kind" of Cacao. The seeds are edible when roasted, but have no resemblance to *Theobroma Cacao*.

According to Aublet's illustrations the pods of *Theobroma guyanensis* are small and oval, distinctly marked with five raised ribs and the leaves are much like those of *T. cacao* but more cordate at the base. The fruit of *T. Sylvestris*, from a plate by the same author, is small, smooth, yet still showing the five divisions of the pod by slight depressions or lines on the outside at equal distances from each other. The leaves are small and suggestive of the ordinary form borne by "Criollo." The pod of *T. bicolor*, Humboldt, is woody in texture, hard and dry, and specimens can be kept for any length of time. I have a specimen, collected in 1885, in the herbarium of this department, and also specimens of the leaves and flowers, and these have since been supplemented by specimens grown in the Gardens.

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FIG. 7.

No. 1.

No. 2.

1. Theobroma Cacao var Forastero.
2. Theobroma Pentagona.

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CHAPTER X.

Diseases, &c.—Insect Pests, Fungi, Vegetable Parasites, Epiphytes, and other enemies.

FORTUNATELY for the cultivator the serious diseases which at present attack the Cacao tree in the West Indies, are few, except the plant is placed in a totally unsuitable position. Perhaps the most common disease affecting the tree, is one which is known under the name of Canker. This cause the stem and branches to dry in certain spots and along certain lines and generally results in the death of the tree.

The cause of this disease is not yet fully clear, but a fungus of the parasitic type has been found on Cacao pods, the allies of which are known to cause canker of the bark on other trees. This has been named *Nectria bainii*, Massee, and will be discussed later. Generally speaking, however, when trees are planted in well drained ground, little or no disease is found; but where a poor surface soil badly drained exists, canker will appear (*Canker of the bark has also been found to be due to a Nectria*—December, 1899.)

There is another disease found in Trinidad, Surinam, Grenada and other places, which attacks the pods in damp weather and causes them to rot and turn black, hence sometimes called "black rot" or "black Cacao." This is due to a parasitic fungus recently studied and forwarded to Kew by the Author, where it was determined as *Phytophthora omnivora*, a fungus akin to that (*Phytophthora infestans*) which destroys the Potato (*Solanum tuberosum.*)

The following extract from De Verteuil's Trinidad, 1884, page 431, reads :—

"*The prosperity of the Colony had now reached its culminating point, Cacao selling at a very high price. But in the year 1727, according to Gunilla, not a disease of the trees exactly, but a blight attacking the pods under certain atmospheric influences, destroyed the crops.*"

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PAGE 433 —"*Governor Nanclares had for his successor Colonel Don Pedro de la Moneda (1757). It was about this time that an attempt was successfully made to re-introduce the Cacao plant. A new species (variety J. H. H.) the Cacao Forastero, which being hardier, although not yielding the same fine quality, succeeded beyond expectation. It is this quality which is still cultivated in our days.*"

Therefore it appears that a thirty-years interval elapsed between the attack of the "blight" on the original Cacao, and the re-introduction. The word "re-introduce," however, would seem to imply that the first Cacao was introduced and not indigenous to the Island but the force of evidence is now against this view.

The following account of this disease is condensed from Bulletin of the Botanical Department for July, 1899 :—The disease is due to a parasitic fungus, known as *Phytophthora omnivora*, a well known relative of that causing the potato disease. This fungus is specially known in Europe by the attack it makes upon young beech seedlings and many other plants both in the open air and when grown under glass.

It is nearly allied to a fungus called *Pythium de Baryanum*, which causes a like destruction among seedling plants, generally known as "damping off." Both fungi are essentially lovers of moisture, and do but little destruction in dry weather. *Phytophthora* reproduces itself in several different ways, and its *oospores* are capable of lying dormant for as much as four years without losing their vitality. (Hartig on Diseases of Trees, 1894, p. 45):—

"Its *gonidia* (such as are formed on the surface of a Cacao pod), are capable of being blown by the wind, or conveyed by animals, insects or men. (Hartig.)"

Tubeuf, in his work on the Diseases of Plants, 1897. p. 116, says :—"Preventive measures against the whole group of fungi to which *Phytophthora* belongs consists in the destruction by burying or burning of diseased and dead parts of host plants, which contain the hybernating *oospores*, by change of crop on infected fields, and by treatment with copper re-agents."

Phytophthora is said to cause an infectious disease. Once a cacao pod is infected, the fungus permeates the pod by means of the slender fungus filaments called *hyphæ* and protruding through,

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appear upon the surface in the form of white mould. The *hyphæ* is enabled to pierce the epidermis from the inside by the action of a solvent substance excreted by the growing tip of the *hyphæ*, the protoplasm secreting a ferment which passes out and enables the tip to corrode and dissolve away the substance of the cell-walls. When the *hyphæ* has protruded from the surface *conidia* or *sporangia* are developed, and these *sporangia* again give rise to swarm cells, which have the power of movement in a drop of water. "When a *conidium* germinates in a drop of dew or rain, the normal process is as follows: The protoplasm in the interior of the pear-shaped *conidium* becomes divided up into about twenty or thirty little rounded masses, each of which is capable of very rapid swimming movements, then the apex of the *conidium* bursts and let these motile *zoospores*, as they are called, escape." (Marshall Ward, p. 280).

Each *zoospore* then swims about for a time and at length comes to rest, commences to grow in about half-an-hour, and then begins to bore its way again into its host.

"The whole process of germination and the entrance of the fungus into the tissues, up to the time when it, in turn, puts out its spore-bearing *hyphæ* again, only occupies four days during the moist warm weather in May, June and July." (Marshall Ward).

It is probable, therefore, that under the conditions of heat and moisture, which exist in Trinidad, the organism will have still more rapid growth than in a temperate climate. The average size of a *conidium*, according to the above author, is 1-400th of an inch long by 1-700th of an inch broad, and the *zoospores* have a diameter of about 1-200th of an inch.

Having such measurements it is easily seen that a single drop of water gives them as much room for movement, comparatively speaking, as a minnow would have in a mill pond. When the fungus filaments, *mycelium* or *hyphæ*, have become fully developed, many branches begin to form an *oospore* or egg-like spore. This spore is formed in a swelling of the free end of a branch of the *hyphæ* and contiguous to it is formed a differentiated branch of the same *hyphæ*, known as an *antheridium*, and between these two organs, fertilization takes place. It has been noted that some 700,000 *oospores* may be found on a surface of less than a square inch. The *oospores* reach the ground in the decomposing part of plants, and it is this fact which has caused us to recommend the entire destruction of all decaying material in so strong a manner, from the time the subject was first dis-

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cussed. Soil containing *oospores*, taken from a diseased seed bed, is said to have given rise to the disease four years afterwards, and it is therefore easy to see how readily these spores may be preserved in the decaying masses of broken and empty pods so often seen upon a cacao estate.

No previous record can be found shewing *Phytophthora* as destroying fruit in the way that it does the cacao pod, its chief ravages having taken place on the leaves of seedling plants.

With regard to remedial measures, nothing has to be added to, or taken from the former recommendations made under this head, when attention was first called to the matter, the essential point of which was, *to destroy all infected material as soon as such comes under the observations of the planter.*

The examination made at Kew reveals the further fact of the existence of a second parasitic fungus upon the material sent home, which proves to be new to science. This fungus has been determined as *Nectria bainii, Massee n. sp.* This organism is one known to botanists as an obligate parasite, and has been shown to produce ulceration or "canker" in different trees. As the canker of the Cacao tree in Ceylon is said to be caused by a *Nectria*, it is obviously the duty of all connected with the culture of Cacao, to watch closely whether the organism which has now been brought to light, is rare or plentiful in our plantations. It has been observed on the young blackened pods. Therefore, it cannot be said that the work is finished in regard to the investigation of these organisms, as it must of necessity be carefully continued, if our planters are to obtain that measure of protection from these fungoid pests which appears to be desirable.

Phytophthora may be readily cultivated in a nutrient fluid, composed of Agar-Agar and mucilage obtained from a half grown pod, sterilized and placed in "Petri" dishes; and its growth can easily be studied in an ordinary "drop culture."

In the "Petri" dishes it produces a characteristic out crop on the surface of the jelly, of small white circles. The disease can be at any time reproduced on the half ripe or full grown pods from this cultivation.

Fortunately there are several *Saprophytic* fungi which cover up and appear to destroy the *conidia* of *Phytophthora*, and besides these I have noticed a small mite or *acarus*, which completely

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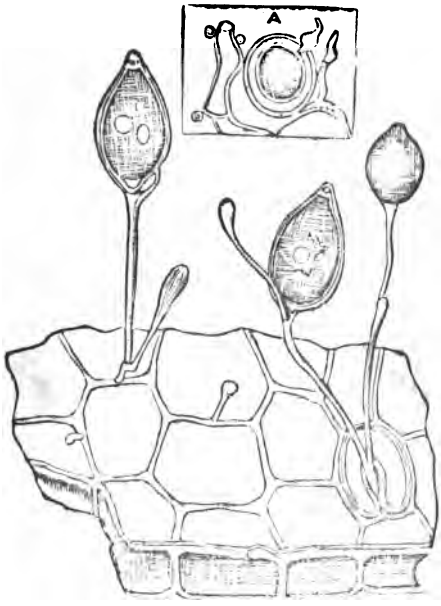

"Phytophthora omnivora."—The Fungus causing the "Cacao Pod" Disease, highly magnified. (After Hartig.) As seen on a beech leaf.

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destroys the whole growth of the parasite from the exterior of the pods. These are probably to be regarded as natural enemies of the fungus, and may help in no uncertain way to prevent its spread.

The facts of the case are now before us, the enemy is known; and it is now quite certain that we are facing no new danger, but one which has long been present, and one which we have not much cause to fear if proper measures are adopted to secure the destruction of infected material.

Persons possessing a microscope may compare the material from infected pods with the drawing of the fungus which I have had made after an illustration in Hartig's work on the diseases of plants.

It is now clear as I anticipated in a previous report, that the disease is propagated largely in the heaps of decaying material which arise from the opened pods being left upon the field, and the first measure to be adopted is that all the empty pods must be removed from the plantations and either buried or burned.

Further study is necessary before anything can be said of *Nectria bainii, Massee;* as we are not as yet advised on the extent of its distribution. This fungus being new has been named by the Kew authorities after Mr. J. P. Bain of Ortinola who was the first to send pods for examination to the office of this Department. On that lot of pods, however, no satisfactory identification of the nature of the disease could be obtained, and it was not until the receipt of other pods that the organisms were recognized. It was then proved that the fungus could destroy a healthy pod in some six or seven days, if inoculated with the *conidia* from an infected pod; showing the infectious character of the disease. From these pods also, the cultures sent on to Kew were obtained. These proved in the words of the Director, Sir W. T. Thistleton-Dyer, "excellent material" for the final identification of the organism causing the disease. It may be mentioned that *Phytophthora omnivora* is an organism known long years ago, and has a wide distribution throughout the world.

A careful experiment was made with beans from pods affected with *Phytophthora* and it was found that samples of diseased and healthy beans fermented and dried at the same time and in the same way, differed very materially in weight.

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In the sample under observation 432 beans from healthy pods weighed 1 lb. but it took 565 beans from diseased pods, to make that weight, which is a loss of nearly 25 per cent.

Professor Harrison called attention to what was probably this disease in his pamphlet on the cacao soils of Grenada, and made analyses of the diseased pods. The following table gives the composition of the dry matter of the whole fruit of the variety Forastero, in a healthy, and in a diseased state, and is followed by remarks by the Professor:—

	Healthy.	Diseased.
a. Organic matters ...	95·93	94·43
Phosphoric anhydride ...	·81	·59
Sulphuric anhydride ...	·18	·19
Sodium chloride ...	·06	·11
Iron peroxide ...	·05	·04
Manganese oxide ...	traces	·01
Calcium oxide ...	·22	·27
Magnesium oxide ...	·65	·59
Potassium oxide ...	2 03	2·85
Sodium oxide ...	·03	·40
Silica ...	·04	·50
	100·00	99·98

Taking into consideration that the healthy fruits analysed were quite ripe, whilst the diseased ones had only attained about two-thirds of their normal development, the variations in the analytical figures have but little significance. As the contents of nitrogen and of the mineral constituents derived from the soil varied but little in the two cases, probably the prevalence of black cacao in any place is not connected with defects in the composition of the soil. Wherever it has been seen occurring the diseased condition has appeared to be closely connected with an undrained condition of the soil or with dampness resulting from over-shading and over-crowding the trees.

The remedial treatment consists in the proper drainage of the soil and judicious pruning of both the cacao and shelter trees to let in light and air. All affected pods should be separated

a. Containing nitrogen ... 1·52 1·64.

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from the apparently healthy ones, broken at a distance from the trees and the husks either burnt or else treated in heaps with quick lime and covered with soil. As an alternative the husks might be treated with a solution of half a pound of sulphate of iron (green vitriol) to one gallon of water or with Bordeaux mixture, but we are satisfied that the destruction of the pods by burning is the most effective process.

(Signed) J. B. HARRISON, M.A.

There are probably several other parasitic fungi which affect the cacao tree, but those mentioned are all which have been properly determined as growing upon the cacao tree in Trinidad.

Among the insect pests of Trinidad there is none for the planter to contend with worse than the "parasol ant" (*Œcodoma cephalotes*) and the "cacao beetles" (*Steirastoma histrionica*) and allied *species Steirastoma depressa* has been found destructive to Cacao in Grenada. The beetles attack the plant by depositing their eggs in crevices of the bark or small wounds, or under the bark in holes made by the insect itself. The larvæ when hatched, cuts long channels through the soft wood of the branches to such an extent that a slight breeze will break away the branch, and sometimes the attack of the grub or larvæ is so persistent as to kill the tree. The larvæ may sometimes be destroyed by probing the holes with a stout wire, thus impaling the creature at its work. This is not always possible, but where the life of a valuable tree is at stake, every endeavour should be made to arrest the destructive progress of the larvæ or grub, which can generally be found and destroyed without much injury to the tree, if a close and careful examination is made. In cutting out a grub, care should be taken to make the wound as small and as little jagged as possible, and to cover it at once with the mixture recommended in a former part of this work for covering of wounds made when pruning.

The Parasol Ant is truly the *bête noir* of the Cacao planter and generally of the Agri-Horticultural community. Until one becomes fully acquainted with the persistent depredations of this creature it is hard to realize what an immense amount of damage is effected by it alone. So much is this the case that the Legislative Council of Trinidad lately passed an Ordinance which enables the Governor to declare certain districts infected, and to enable planters to take means for their destruction.

The destruction of this pest is extremely simple, but from the persistence with which impregnated females seek the spots

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that contained former nests, an equal persistence and careful watching is needed to keep the ground clear. Where cultivation is conducted in proximity to a large area of forest lands the matter becomes a very difficult one indeed, for not only have the local nests to be destroyed but also those in the distant woodlands, and especially the large nests, a raid from which will frequently do irreparable damage to a plantation in a single night. There are many methods in use for compassing their destruction, the most common being that of digging out and puddling with water. Some forms of destruction are suitable for one locality and some for another. Where a constant watch for new nests is regularly kept, as at the Royal Botanic Gardens, they do not become of any great size before they are discovered, and a dose of coal tar poured into their nest effectually disposes of them, once and for all, at that particular spot, as they never again return where coal tar has once been applied. Other nests can best be attacked by using the fumes of sulphur driven in by bellows or fan. A handy machine lately introduced, costing some $24.00, known as the "Asphyxiator," can be used with sulphur or any other chemical producing deadly fumes. These ants will, when on raid from a large nest, make a track as much as 10 or 12 inches wide (from which every portion of herbage is carefully cut away) for the purpose of carrying home to the nest the leaves they cut from the trees, and several large trees are often completely cleared of leaves and flowers in the space of a single night. Each ant is able to carry a piece of leaf half an inch in diameter, and hold it in its mandibles above its head, resembling when on the march the sails of a fleet of liliputian schooners dipping and swaying to the wind. Belt, in the Naturalist in Nicaragua, studied these insects and came to the conclusion that the leaf is not used primarily for food, but is chewed up, and placed in a position where the mycelium of certain fungi at once attack it, and form food for the ants and their larvæ. Certain it is, that a peculiar mycelium is found permeating the inside of every nest, and gives to it a peculiar odour of its own, which once recognized, is again easily distinguished. Belt's observation has since been confirmed by the observations of the writer, who for several years had artificial nests under observation. In these the ants could be seen feeding themselves and their larvæ upon the conidia of the fungus, which is actually *cultivated for food* by these creatures.

There are several species of aphides or plant lice &c., which attack Cacao, but unless the plant is in bad health from some other cause they seldom do any great harm, especially if cleanliness and order, are the rule on the plantation. It has been found however that it is quite possible for any biting or sucking insect

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to infect a Cacao pod with the spores of *Phytophthora omnivora* or with those of *Nectria*. With these are found an attendant species of ant, as occurs on many other species of plants, but the ant in this case is practically harmless.

Wood ants also infest trees on which there is decayed wood, or wood in process of decay; but the remedy for such attacks is obviously the removal of all dead or dying wood, which should never be allowed to accumulate on a well ordered plantation.

Among the vegetable parasites there are one or two species of *Loranthaceæ*, which affect Cacao. These are mistletoe-like plants which are true parasites, and do considerable harm to the trees, and should be at once removed with a sharp cutting instrument as soon as seen. If the branch on which they are affixed can be spared, it should also be removed, as it is liable to reproduce the plant from the seat of union between the parasite and the tree.

There are also one or two species of *Cuscuta* or "Dodder" which cause considerable damage. These plants are known as "God Bush" and "Love Vine" in several of the West Indian Islands. In a well managed plantation they are at once removed from the trees in their younger stage, for if allowed to spread they weaken and eventually destroy the trees they affect.

There are a large number of so-called "parasites or orchids" which are found to grow on Cacao trees. Among these may be mentioned *Tillandsia*, *Peperomia*, *Anthurium*, *Philodendron*, *Marcgraavia*, and several species of true orchids.*

True parasites such as *Loranthus* and *Cuscuta*, evidently weaken the tree by the abstraction of its juices, but the epiphytical growths do not take any nourishment from the tree itself, but obtain their nourishment direct from the atmosphere and from particles of food carried to their roots by the rain that falls, only affixing themselves to the tree as a holding place or suitable position for carrying on their life's work.

It is doubtful therefore if they do any direct harm to the tree, but nevertheless, a plantation having trees covered with such growth cannot be said to be under good cultivation, and it

* The word "Orchids or Parasites" is applied indiscriminately in Trinidad to any kind of parasitical or epiphytical growth which appears on the Cacao tree.

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is certainly conducive to the maintenance of the health of the tree that they should be regularly removed, as they prevent a due circulation of air.

With regard to mosses and several of the lower forms of cryptogamic life which infest the trunks and branches of Cacao trees, it is sometimes argued that they are beneficial, others however declare it best to remove them. One reason given is, that if they are removed, the process of removal will invariably destroy numbers of the flower buds which are produced on the trunk and branches. That this argument is sufficient I much doubt, and I should be more inclined to maintain the trunk and branches (which are the fruit producing portion) in as clean a state as possible, taking care however, to enjoin the workmen to remove these growths with the greatest care possible, so as not to injure the "cushion" or node from whence the flowers are produced.

The squirrel and the rat, are both great enemies to the Cacao planter, and it is always found that they select the best class of pods, not alone on account of the thinness of their pods, but also owing to the greater amount of sweetness that the pulp of the *Criollo* varieties possess. It is for this reason that in some instances the *Forastero* or thick podded varieties are planted, instead of the finer sorts, and the same argument applies to the damages done by mice, which are plentiful in some districts. The rat-like oppossum, known locally as "Manicou Gros Yeux," is similarly credited with doing damage to Cacao, and is invariably destroyed when found, on that account.

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CHAPTER XI.

Export of Cacao.—Value of Estates.—Buildings required.—Labour, &c.

Export of Cacao.

THE export of Cacao from Trinidad has been gradually increasing for many years, and it is probable that the exports will probably continue to increase for some years to come as the area under cultivation is being extended largely, year by year, as is shewn by the statistics of the Crown Lands Office. The following table which has been kindly compiled for me by the direction of the Collector of Customs (Hon. R. H. McCarthy) and is a valuable record of the Exports of Cacao from Trinidad during the last decade:—

RETURN OF EXPORTS OF CACAO.

	Produce of Colony		Other than Produce of Colony	
Years.	Quantity in lbs.	Value £.	Quantity in lbs.	Value £.
1891	16,188,493	439,786	2,382,784	69,694
1892	25,041,635	648,103	3,879,542	113,061
1893	19,106,553	535,055	2,707,491	80,415
1894	21,608,384	509,808	2,920,926	77,756
1895	29,458,813	620,634	3,098,772	73,978
1896	23,481,848	452,141	4,574,965	98,447
1897	23,840,665	532,123	3,917,654	73,567
1898	24,340,960	705,956	3,855,264	106,316
*1899	25,645,760	679,231	3,182,144	80,601

* To half year ending 30th June.

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The exact acreage producing these crops is unknown as no facilities exist for ascertaining what acreage is under cultivation.

In Ceylon the area under cultivation in 1892 was estimated at 12,000 acres. The crop for 1891 was 20,000 cwts. Trinidad therefore produced seven times as much as Ceylon at that date.

It will be seen from this, Mr. McCarthy's table, what an important article of commerce this product is, and as the cultivation is spreading in nearly every district of the Island it is probable that in a few years' time the value of the export of Cacao will exceed that of all other vegetable products combined. With such a fact before them, it is especially incumbent on the Cacao planters of Trinidad to seek every means to improve their produce so as to maintain a superior article and to be first in the markets of the world. The Ceylon planter has succeeded wonderfully well in obtaining good prices, but it is questionable whether his Trinidad *confrère* does not obtain from his *Forastero* trees, a better return per acre, than his Ceylon brother does. From the late Dr. Trimen's Report it appears almost certain that the quality of the bean as grown from seed imported from Trinidad is improved by Ceylon culture.

The intending planter can obtain Crown Lands from the Government of Trinidad on petition at the upset price of one pound sterling per acre, exclusive of survey and other fees, but all lands are subjected to public competition before the grant is made, so that if two applicants require the same ground, it is finally obtained by the one who has the longest purse, or who is willing to pay more than his competitor, above the upset price.

There are in the usual course of business small and large estates constantly passing through the market, and the price of these vary according to the locality in which they are situated, and the quality of the land. The value of an estate is usually estimated at per tree, or per 1,000 trees and not at per acre, and what might be worth in some districts but 60 cents per tree, would in other and celebrated districts be worth as much as $2 or 8/4d. per tree.

The best course for the intending investor is to make himself acquainted with the several districts and await his opportunity, residing in the colony and adding to his experience in the meantime. In Trinidad as everywhere else, there are those present

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who will not hesitate to recommend estates to buyers simply for the commission they could get from the seller, and there are others again who will accompany an intending buyer in a friendly way to visit an estate and afterwards attempt to recover an exorbitant fee for their services. Let the investor beware of such or he will probably be landed in a similar plight to that of "Mark Tapley," but it is questionable whether there is "any credit in being jolly" under such circumstances. Good estates have to be waited for, and are always readily disposed of, so that the buyer should quickly make up his mind when he sees "a thing going," which is fairly in accord with his ideas.

The yield per acre, or the yield per tree of a Cacao estate is the best test of its value, especially if reliable reference can be made by the seller to the crop harvested for two or three preceding years. Cacao trees begin to bear in the third or fourth years, and sometimes precocious trees will even begin earlier than this, but it is not well to let them produce a crop, as bearing will infallibly retard their growth.

Dr. Morris writes (Cacao and how to cure it):—

At the sixth and on their ninth years, the Cacao tree should be in fair bearing, but they seldom reach their prime before their twelfth or fifteenth year. After this period where the trees have been carefully established and well cultivated, a Cacao estate is a comparatively permanent investment, and it may be expected to continue in bearing and yield remunerative returns for some fifty, eighty or a hundred years. In fact, if old and exhausted trees are regularly and systematically replaced or "supplied" there is practically no limit to the duration of a Cacao estate.

The yield per tree will be seen to depend entirely upon the quality of the land, the size of the tree and various other attendant circumstances, but is generally considered that a yield of 1·6 lbs. per tree which will be 10 bags of 165 lbs. each to 1,000 trees, is a first-class yield, 5 bags per 1,000 trees or 0·8 lbs. per tree would be considered a poor yield.

Taking our trees to be planted at 15 feet apart, there will be 193 trees per acre nominally (of course it is never possible to maintain this regularity, on account of roads, drains, &c., but for the sake of method in the estimate we accept this number) and the yield per acre will be 193 × 1·6 lbs. = 308·8 lbs. which, valued at 80/- per cwt., will produce the sum of £11 per acre. Calculating the trees at 12 feet apart we get 302 to the acre, and these at 1·5 lbs. per tree, the value per acre would be £16 3.

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These statements were freely criticised on the issue of the first edition, and a prominent planter wrote: "It is an error to state that a yield of 1·6 lbs. per tree, which will be 10 bags of 165 lbs. each, to 1,000 trees, is a first-class yield. That is an average, a high average possibly of Trinidad cacao estates; but a first-class yield could not be under 12 bags per 1,000 trees, and in many cases 15 bags."

I see no reason however to alter the figures given in the first edition.

The working expenses of a plantation may be calculated at £3 to £5 per acre annually, more or less according to circumstances, facilities for obtaining labour, easy transit of produce, &c., &c.

It is calculated that an estate can be established by the contract system at a cost of about £12 to £15 per acre, exclusive of buildings. A record has been published of a single tree which made a yield of 36 lbs. in one year, but this was exceptionally placed, and well treated to manure. In the Royal Botanic Garden 7 lbs. of dry Cacao has been obtained from a single tree at one picking.

A method of calculating the value of an Estate was given in the Agricultural Record for 1892 as follows:—"Note the quantity of bags produced; that multiplied by 100 or 150 according to the quality of Cacao. facility for transport, healthy locality, buildings on the spot, &c., &c., will give correct value of the estate in dollars." This is to say a latitude of 50% is allowed an estate for the possession of the points mentioned.

Buildings Required.

The buildings required on a Cacao estate are few.

Where the proprietor is resident—and he always will be, if he wishes his estate to pay—there must be a comfortable residence, and therefore the expenditure under this head cannot be laid down, but must be left to the individual taste of the planter and the extent of his means.

The most important buildings on a Cacao estate are the drying houses and sweating boxes. These are generally built all in one. The sweating boxes being placed under the drying

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floors, but sometimes they are separated, and we believe that this latter course is the best, as during the process of fermentation much moisture is given off by the bean and this cannot be conducive to the quick drying on the floors above.

The cost of houses for an estate of 300 acres would probably be some £200 to £250 each or perhaps more, if substantial buildings are to be erected and artificial drying resorted to, and several of these would be required as an estate developed. A single house will be sufficient to commence with on an estate made from Virgin Forest as the crop will be gradually increasing from year to year, and the necessary drying space should be extended so as to keep pace with the number of trees coming into bearing, but it is always better to have ample drying space, than to be for one moment cramped for room; for much is lost and nothing gained by such a policy, as there is a liability to spoil produce when there is not sufficient room in the drying houses.

It is generally considered that 80 square feet of drying surface is sufficient space for drying the produce of 1,000 trees, taking the crop of the year from beginning to end. If the planter therefore can find out what it will cost him to provide this area he can easily estimate for larger surfaces, the cost of building entirely depending upon the district in which the plantation is situated.

Next to the drying house a good storeroom and office should be provided and a proper range of labourers' barracks may be required where labour has to be brought from a distance.

Labour, &c.

It will be found much better to attach labour to an estate by the allowance of house room, provision ground or other privilege, than to employ casual labour as it presents itself, as there is much more interest taken in the work when the labourer in a measure "belongs to the estate," and looks upon it as his home.

Skilled labour is highly requisite on a Cacao estate, *i.e.*, the labourer must be accustomed to the work, and the higher the class of labourer employed the better will the estate be worked. Such labour is however not always obtainable, but it is certainly the best when it can be had. We are not here speaking of the manager, foreman or ganger, but of the field hands for the purpose of carrying on the general work of the plantation. With

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managers and foreman generally, it is evidently to the interest of the proprietor to employ only those who take an intelligent interest in the work they have to carry out, and who take pride in preparing a quality of produce which shall always bear the highest stamp. With such men careful experiments may be carried on, which will lead to improvement and economy when compared with the methods now in use.

The cost of labour is an item always enquired about by a new comer, and at times not easily answered, but he will understand that this must vary with the district and only a general idea can be given in a work of this kind.

The rate of wages on a Cacao estate varies according to the work performed by the labourer, from 25c. to 60c. per day, and much of the work is done by task, a system which is much preferred by the labourer.

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CHAPTER XII.

The Agricultural Chemistry of Cacao.

THIS Chapter is kindly contributed by Prof. J. B. Harrison, M.A., Government Analyst, &c., &c., of British Guiana.

The main features of the chapter first appeared in an official report by the Professor on the soils of Grenada to the Government of that Island.

The composition of the different parts of the cacao tree has been treated upon by Marcano of Venezuela *(a)* and in part by Boname, late of Guadeloupe, now of Mauritius *(b)*. Opportunities for studying the requirements of the plant as represented by the composition of the mature trees themselves being very limited we accept for guidance the result given by Marcano. This authority estimates that a cacao tree twenty years old is made up of—

Trunk	49·5
Large branches	21·1
Medium branches	11·
Small Shoots	12·
Leaves	6·4
	100 0

(a) Essais d'Agronomie Tropicale. V. Marcano.

(b) La culture de la canne à sucre à la Guadeloupe. Ph. Boname

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and that a plantation of trees of this age growing on one acre will contain—

Nitrogen	201	lbs.
Phosphoric anhydride ...	95	„
Potash	251	„
Lime	400	„
Magnesia	111	„

whilst the so-called suckers and other young shoots trimmed annually from the trees contain*—

Nitrogen	84	lbs.
Phosphoric anhydride ...	49	„
Potash	42	„
Lime	66	„
Magnesia	20	„

These together with the leaves which he states contain—

Nitrogen	39	lbs.
Phosphoric anhydride ...	75	„
Potash	30	„
Lime	32	„
Magnesia	10	„

are practically in all cases yearly returned to the soil.

The fruit, of which the husks may or may not be returned to the soil according as to whether the pods are or are not broken on the field, are estimated to remove as follows :—

	If whole fruit removed from the field.	If the pods are broken and left in the field.	
Nitrogen ...	15·5	8·7	lbs.
Phosphoric anhydride	7·9	4·5	„
Potash ...	22·1	3·7	„
Lime ...	6·5	1 4	„
Magnesia ...	2·3	1 0	„

* This estimate appears to be excessive.

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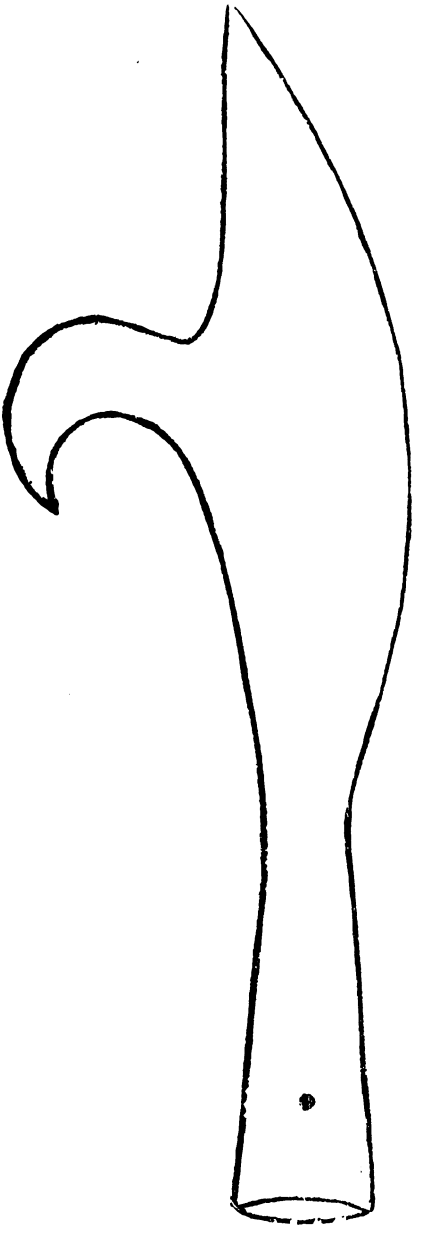

Cacao Hook—Improved

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From these figures it appears that the cacao tree whilst storing up in the plant itself relatively large proportions of the important elements of plant food present in the soil, requires for the yearly productions of young shoots, leaves and fruit not less than 138 lbs. of nitrogen, 64 lbs. of phosphoric anhydride, 94 lbs. of potash, 104 lbs. of lime and 31 lbs. of magnesia. Under careful conditions of agricultural practice, however, of this great annual drain upon the soil but 8·7 lbs. of nitrogen, 4·5 lbs. of phosphoric anhydride, 3·7 lbs. of potash, 1·4 lbs. of lime and 1 lb. of magnesia are necessarily removed from it, the remainder becoming more or less available again for plant food by the decomposition of the fallen leaves, pruning and husks upon the land. Of the, in round numbers, 130 lbs. of nitrogen returned to the soil a considerable proportion, possibly 20 to 30 per cent, may be lost during the decomposition of the vegetable matter, but where the trees are shaded by the nitrogen collecting Bois Immortel or Oronoque trees (*Erythina velutina* and *E. umbrosa* which are used on the islands, or *E. glauca* which is used in Guiana?) doubtless much of the amount thus lost is recouped to the soil.

These considerations lead to the conclusion that a good cacao soil should be one capable of yielding to the tree in the course of years a somewhat high proportion of the important constituents of plant food without exhaustion, and also capable of rapidly rendering again available the large quantities of manurial matter returned to it in the forms of prunings, leaves fallen and broken pods. It must in addition be one in which the course of nitrification readily takes place; in other words, a fairly rich friable and well drained soil of *prime importance* for the successful production of cacao.

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The following are types of good cacao soils recently examined in the Government Laboratory, British Guiana :—

	Demerara.	Grenada.				St. Vincent.	*Trinidad.	Nicaragua.	Surinam.	
		No. 1.	No. 2.	No. 3.	No. 4.				No. 1.	
1 Organic matters & combined water	9·031	7·644	10·442	10·993	9·688	3·046	3·768	10 815	15·452	10·810
Phosphoric anhydride	·087	·082	·184	·044	·058	.114	·084	·293	·139	·109
Sulphuric anhydride	·018	·118	traces.	traces.	·027	·055	traces.	·141	·047	·358
Chlorine	traces.	traces.	nil.	traces.	traces.	traces.	nil.	·007	trace.	trace.
Iron peroxide	4·783	9·085	9·485	18·672	12·033	9·574	3·910	7·000	5·952	7·567
Alumina	9·217	13·628	10·024	17·140	12·710	8·889	2·038	4·717	16.076	14·668
Manganese oxide	·347	·191	·313	·379	·249	·435	·127	·163	nil.	·108
Calcium oxide	·596	1·335	2·379	·481	1·183	4·981	·356	2·250	·495	·408
Calcium carbonate	·032	·236	·026	·185	.099	nil.	nil.	nil.	nil.	nil.
Magnesium oxide	·404	1·367	3·367	1·261	·680	2.418	·495	·217	1·071	1·547
Potassium oxide	·291	·254	·343	·169	·428	·178	·118	·619	1·072	1·042
Sodium oxide	·208	·393	·574	·197	1·102	·369	·278	1·184	·258	·271
Insoluble silica & silicates	74·986	65·667	62·863	50·509	61·743	69·941	88·826	72·594	59·438	63·112
	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000	100·000
1. Containing nitrogen	·262	·309	·271	·286	·224	·205	·100	·228	·306	·272
Water retained by air died soil ...	6·5	8·5	12·4	14·3	9·6	8·1	1·8	8·0	11·	7·5

*Note by J.H.H.—This sample was not selected on account of heavy yields, but for quality and flavour of produce.

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The following are examples of poor Cacao soils, upon which the yields are very unsatisfactory :—

	Demerara.					Grenada.		
	No. 1.	No. 2.	No. 3.	Surinam.	St Vincent.	No. 1.	No. 2.	No. 3.
Organic matters and combined water...	2·786	4·471	1·921	18·701	3 029	14·540	8·035	12·897
Phosphoric anhydride	·021	·020	·002	·157	·042	·024	·120	·050
Sulphuric anhydride	·017	·111	nil.	nil.	·045	·037	·028	·099
Chlorine	trace.	nil.	nil.	trace.	trace.	trace.	traces.	trace.
Iron peroxide	2·231	4.081	·992	3·874	9·695	14·300	9·642	22·349
Alumina	3·353	7·214	1·834	15·269	7·374	11·803	15·403	26·925
Manganese peroxide	·008	·005	·250	nil.	·487	·109	·084	320
Calcium oxide	trace.	·225	·017	·010	4·787	·534	·196	·210
Calcium carbonate	nil.	nil.	nil.	nil.	trace.	trace.	·152	·264
Magnesium oxide	·423	·041	·072	·661	1·899	·422	·160	·314
Potassium oxide	·109	·051	·029	·041	·083	·041	·097	·056
Sodium oxide	·100	·225	·037	·003	·704	·398	·360	·230
Insoluble silica & silicates	90·952	83·556	94·846	61·284	71·855	58·387	65 723	36·286
	100·300	100·000	100 000	100·000	100·100	100·000	100·000	100·000
1. Containing nitrogen	·077	·057	·063	·265	·075	·137	·109	·171
Water retained by air dried soil ...	1·3	1·9	·4	7·6	7·6	8·2	10·4	14·1

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For comparison, I insert the following Analyses made by P. Carmody, Esq., F.L.S., Government Analyst of Trinidad, of Soils from Cocoa Estates in Trinidad and Venezuela:—

ANALYSIS OF SOILS, SANGRE GRANDE DISTRICT, TRINIDAD.

Sample No.	1	2	3	4
Composition of Air Dried Soils.				
Water	6.04	3.56	9.48	3.66
Dry Soil...	93.96	96.44	90.52	96.34
	100.00	100.00	100.00	100.00
Composition of the Dry Soil.				
*Loss on Ignition ...	6.641	6.097	7.004	8.948
Iron Oxide, $Fe._2 O._3$	2.327	2.343	2.143	2.440
Alumina, $Al._2 O._3$	3.798	5.171	5.652	5.313
Lime, Ca. O.	.128	.084	.124	.148
Magnesia, Mg. O.	.445	.498	.405	.284
Potash, $K._2 O.$	.183	.223	.267	.217
Soda, $Na._2 O.$	.173	.021	.081	.142
Phosphoric Acid, $P._2 O._5$	.133	.096	.117	.116
Sulphuric Acid, $S. O._3$	.111	.053	.102	.025
Chlorine, Cl.	.005	.006	.008	.093
Insol. Silicates ...	86.056	85.408	84.097	82.364
	100.000	100.000	100.000	100.000
*Containing Nitrogen ...	.131%	.107%	.140%	.165%
* ,, Carbon ...	.234	.454	.139	.224
Equal to Humus ...	.403	.784	.242	.386
Nitrogen as Nitric Acid...	.00253	.00298	.00235	.00335
Readily Available Potash and Phosphates.				
Potash, $K._2 O.$	·0914%	.1290%	.1162%	.0881%
Phosphoric Acid, $P._2 O._5$	.0510	.0564	.0159	.0465

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	Venezuela (Good Soil.)	Pluck. I. Black.	Pluck. II. Red.	Ortinola. I. Red.	Ortinola. II. Black.	La Compensacion. I.	La Compensacion. II.	San José. I.	San José. II.	Montserrat. I.	Montserrat. II.
Composition of Air Dried Samples.											
Water...	10.74	9.47	9.20	1.60	1.04	5.82	4.32	4.70	4.98	4.23	2.58
Dry Soils	89.26	90.53	90.80	98.40	98.96	94.18	95.68	95.30	95.02	95.77	97.42
	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Composition of the Dry Soil.											
*Loss on Iguition	7.610	7.700	8.200	3.850	2.870	9.890	6.700	3.820	9.000	5.340	3.660
Iron Oxide, $Fe_2 O_3$	6.200	14.920	14.210	5.000	4.410	12.500	13.330	7.830	9.690	3.860	3.679
Alumina, $Al_2 O_3$	...	...	...	...	...	...	...	...	..	4.410	2.450
Lime, Ca. O.	.594	.540	.517	.700	.513	.403	.231	.284	.305	.218	.133
Magnesia, Mg. O.	.782	.291	.376	.101	.076	.246	.212	.205	.208	.104	.246
Potash, K_2 O.	.392	.264	.233	.212	.218	.250	.239	.237	.247	.126	.114
Soda, Na_2 O.	.177	Not determined		...	...	Not determined		...	...	.286	.267
Phosphoric Acid P_2 O_5	.147	.231	.237	.142	.155	.149	.120	.208	.222	.139	.113
Sulphuric Acid, S. O_3	.036	.056	.077	.029	.025	.043	.048	.027	.039	traces.	traces.
Chlorine, Cl.	.016	.004	.004	.004	.006	.0 9	.008	.005	.007	.005	.006
Insol. Silicates	84.046	75.994	76.146	89.962	91.727	76.510	79.142	87.334	80.282	85 512	89.636
	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.000	100.00
*Containing	.71o/o	.143o/o	.127o/	.128o/o	.110o/o	.067o/o	.073o/o	.067o/o	.110o/o	.087o/o	.093o/o
* "	...	...	...	...	...	...	...	...	...	...	...
Equal to Humus	.225	.346	.292	.251	.298	.290	.346	.375	.351	.249	...
Nitrogen as Nitrates ...	.00636	.0012	.0915	.00323	.00157	.00119	.30097	.00072	.00094	.0010	.0009
Readily Available Potash and Phosphates.											
Potash, K_2 O.	.1707o/	.138o/o	.1311o/o	.1225o/o	.1466o/o	.1052o/o	.1071o/o	.1698o/o	.1177o/o	.086o/o	.059o/o
Phosphoric Acid, P_2 O_5	.082	.077	.091	.071	.078	.102	.101	.101	087	.062	.104

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The samples from Grenada, St. Vincent and Demerara were personally selected, whilst those from Trinidad and Nicaragua were given to us and described as very fertile cacao soils by J. H. Hart, Esq, F.L.S., the Superintendent of the Botanic Gardens, Trinidad. With the exceptions of the Surinam, Demerara and Trinidad samples, all are of soils arising from the degradation of lavas and volcanic debris, rich in soda lime felspars. As a rule these fertile cacao soils are fairly rich in nitrogen, and contain a somewhat high amount of potash, of which a relatively high proportion was found to be soluble in 1% citric acid solution whilst the proportion of phosphoric anhydride present appears to be of lesser importance. They can, we consider, be safely regarded as reliable types of the composition of really fertile cacao soils.

As far as present experience goes in the selection of good reliable soils for cacao cultivation, if the physical conditions are in accordance with those mentioned in a previous paragraph, the most important point chemically is that the soil should contain an ample supply of available potash, a fair supply of nitrogen and a medium one of phosphoric anhydride and of lime, and should have either from its chemical composition or its physical condition a marked retentive power for hygroscopic moisture. On soils of this kind large and remunerative crops of cacao may reasonably be expected even during seasons during which on other lands crops may suffer from drought.

In order to obtain reliable data as to the composition of cacao grown under fairly favourable conditions at low elevations, Charles Ross, Esq., of Pln. Land of Canaan, Demerara River, supplied us with a large number of freshly gathered ripe pods of Cacao of two varieties: 1st, the small podded, thick, smooth skinned variety with flat beans, known as Calabacillo; and 2nd, the large podded somewhat thick rough skinned variety with full rounded beans, known as "Forastero." The former is the variety agriculturally best suited for heavy lands, being the hardiest of all varieties, and giving on low lying land, by far heavier yields of cured Cacao than "Forastero" does. In addition we obtained from him cured beans of these varieties. Many other varieties are to be found growing in greater or less

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abundance in the cacao groves of British Guiana including the Criollo or Caracas kind, but as the bulk of the crops appears to consist of Forastero and Calabacillo Cacao, principally of the former, attention was confined to them.

The fresh pods were found to yield as follows:—

	Calabacillo.	*Forastero.*
Husk ...	80·59 ...	89·87
Pulp ...	7·61 ...	4·23
Cuticles of Beans	1·77 ...	·50
Kernels of Beans	10·03 ...	5·40
	100·00	100.00

The yields of cured cacao are 37·5 and 35·6 per cent. of the beans and pulp of the two varieties respectively. Hence 100 lbs. of the fruit of Calabacillo will yield 7·25 lbs. of fermented cured cacao and 100 lbs. of the fruit of Forastero 3·6 lbs. There would appear to be a distinct advantage in growing cacao of the variety Calabacillo; but the difference in the market value of the small flat brands of this variety and in that of the large plump beans of Forastero very materially reduces the apparent advantage while comparatively upon light soils of higher elevation the agricultural yield of Calabacillo is frequently less than that of Forastero.

The fresh fruits were rapidly divided up into the outer husks, the cuticles of the beans and their adherent pulp, and the inner kernels of the beans or cacao nibs proper. The cured beans were also divided into cuticles and inner kernels. After weighing, all parts of the fresh fruit were dried at a temperature of about 140° F. uutil they ceased to lose weight, the loss of moisture noted, and the dry material carefully ground up and sampled.

Analyses were afterwards made of these portions and the results calculated back to the original state of the fruits as received.

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The following show the detailed composition of the fresh fruits of each variety, of the various parts of the fruits, and the distribution of the constituents in the parts of the fruit :—

TABLE I.

Whole Fruit of Cacao, Variety "Calabacillo."

Water	78·790
1. Albuminoids	1·470
2. Theobromine	·234
3. Caffeine	·015
4. Indeterminate nitrogenous matters ...	·067
Fat...	3·093
Glucose	·274
Sucrose	·006
Starch	·844
Astringent matters	2·332
Pectin, etc.	5·221
Cacao-red	·888
Digestible fibre	5·405
Woody fibre	3·122
Tartaric acid free	·324
Acetic acid free	·054
Tartaric acid combined	·716
Iron peroxide	·008
Magnesia	·120
Lime	·042
Potash	·468
Soda	·038
Silica	·007
Sulphuric anhydride	·044
Phosphoric anhydride	·152
Chlorine	·032
	99·267
1. Containing nitrogen	·212
2. „ „	·078
3. „ „	·004
4. „ „	·030
Total nitrogen	·325

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TABLE II.

CONSTITUENTS OF THE VARIOUS PARTS OF THE CACAO FRUIT, VARIETY "CALABACILLO."

	Kernels of Beans.	Cuticles and pulp.	Husks.
Water	37·637	87·600	82·893
1. Albuminoids	6·696	·918	·760
2. Theobromine	1·352	·241	·094
3. Caffeine	·108	·341	nil.
4. Indeterminate nitrogenous matters ...	·531	traces.	·169
Fat	29·256	·444	·146
Glucose	·991	·725	·132
Sucrose	traces.	·066	traces.
Starch	3·764	·945	·469
Astringent matters and tannin ...	5·004	·395	2·225
Pectin, etc.	·657	·815	1·710
Cacao-red	2·952	·511	·675
Digestible fibre, etc. ...	5·112	4·652	5·411
Woody fibre	3·030	1·346	3·341
Tartaric acid, free ...	·079	·439	·347
Acetic acid, free ...	nil.	nil.	·064
Tartaric acid, combined...	·477	·303	·796
Iron peroxide	·032	·004	·005
Magnesia	·324	·114	·099
Lime	·054	·054	·039
Potash	·142	·190	·454
Soda	·239	·041	·041
Silica	·016	·002	·006
Sulphuric anhydride ...	·079	·021	·042
Phosphoric anhydride ...	·749	·115	·082
Chlorine	·019	·018	·036
	100·000	100·000	100·000
1. Contains nitrogen ...	1·071	·147	·121
2. „ „ ...	·416	·077	·029
3. „ „ ...	·031	·012	nil.
4. „ „ ...	·085	nil.	·027
Total nitrogen ...	1·603	·236	·177

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TABLE III.

DISTRIBUTION OF THE CONSTITUENTS OF THE FRESH CACAO FRUIT, VARIETY "CALABACILLO."

Percentage of	Kernels of Beans.	Cuticles and pulp.	Husk.
	10·03	9·38	80·59
Water	3·7751	8·2169	66·7980
1. Albuminoids	·6716	·0861	·6125
2. Theobromine	·1355	·0226	·0757
3. Caffeine	·0108	·0038	nil.
4. Indeterminate nitrogenous matters ...	·0532	traces.	·0136
Fat	2·9343	·0413	·1177
Glucose	·0994	·0680	·1064
Sucrose	traces.	·0062	traces.
Starch	·3775	·0886	·3780
Astringent matters ...	·5019	·0370	1·7931
Pectin, etc.	·0659	·0764	1·3800
Cacao-red	·2961	·0479	·5438
Digestible fibre, etc. ...	·5127	·5316	4·3607
Woody fibre	·3039	·1262	2·6917
Tartaric acid, free ...	·0079	·0412	·2748
Acetic acid, free ...	nil.	nil.	·0543
Tartaric acid, combined	·0478	·0284	·6399
Iron peroxide... ...	·0032	·0004	·0048
Magnesia	·0325	·0107	·0765
Lime	·0050	·0051	·0314
Potash...	·0844	·0182	·3659
Soda	·0240	·0038	·0101
Silica	·0016	·0002	·0041
Sulphuric anhydride ...	·0080	·0020	·0338
Phosphoric anhydride...	·0751	·0408	·0661
Chlorine	·0019	·0016	·0290
	10·0293	9·3750	80·4616
1. Contains nitrogen ...	·1074	·0138	·0975
2. „ „ ...	·0417	·0072	·0233
3. „ „ ...	·0031	·0011	nil.
4. „ „ ...	·0085	traces.	·0217
Total nitrogen ...	·1607	·0221	·1425

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TABLE IV.

WHOLE FRUIT OF CACAO, VARIETY "FORASTERO."

	Water	81.877
1.	Albuminoids	1·234
2.	Theobromine	·152
3.	Caffeine	·015
4.	Indeterminate	·175
	Fat	1.800
	Glucose	·927
	Sucrose	·054
	Starch	·780
	Astringent matters	·424
	Pectin, etc.	1·022
	Cacao-red	·684
	Digestible fibre	4·097
	Woody fibre	5·055
	Tartaric acid, free	·255
	Acetic acid, free	·053
	Tartaric acid, combined	·564
	Iron peroxide	·010
	Magnesia	·119
	Lime	·040
	Potash	·368
	Soda	·011
	Silica	·008
	Sulphuric anhydride	·033
	Phosphoric anhydride	·147
	Chlorine	·006
		99·910
1.	Containing nitrogen	·198
2.	„ „	·046
3.	„ „	·004
4.	„ „	·028
	Total nitrogen	·278

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TABLE V.

CONSTITUENTS OF THE VARIOUS PARTS OF THE CACAO FRUIT, VARIETY "FORASTERO."

	Kernels of Beans.	Cuticles and pulp.	Husks.
Water	36·567	83·030	84·538
1. Albuminoids	4·826	1·271	1·017
2. Indeterminate nitrogenous matters ...	2·725	nil.	·031
3. Theobromine	·822	·348	·098
4. Caffeine...	·222	·059	nil.
Fat	30·602	·421	·142
Sucrose	·165	1·001	·969
Glucose	·917	·091	nil.
Starch	6·038	1·305	·445
Astringent matters ...	4·894	·108	·172
Pectin, etc.	1·380	1·126	·995
Cacao-red	1·543	·705	·631
Digestible Fibre ...	2·821	6·564	4·045
Woody Fibre	3·458	2·455	5·288
Tartaric acid, free ...	·038	·606	·250
Acetic acid, free ...	nil.	trace.	·059
Tartaric acid, combined...	·487	·351	·580
Iron peroxide	·032	·010	·009
Magnesia	·454	·073	·101
Lime	·105	·030	·037
Potash	·635	·248	·358
Soda	·068	·015	·073
Silica	·016	·003	·008
Sulphuric anhydride ...	·048	·031	·032
Phosphoric anhydride ...	1·045	·098	·096
Chlorine	·032	·061	·026
	100·000	100·000	100·000
1. Containing nitrogen ...	·772	·203	·163
2. „ „ ...	·436	nil.	·005
3. „ „ ...	·271	·107	·030
4. „ „ ...	·064	·017	nil.
Total nitrogen ...	1·543	·327	·190

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TABLE VI.

DISTRIBUTION OF THE CONSTITUENTS OF THE FRESH CACAO FRUIT, VARIETY "FORASTERO."

Name of Part.	Kernels of Beans.	Cuticles and pulp.	Husk.
Per cent. of part ...	5·40	4·73	89·7
Water	1·9746	3.9273	75·9750
1. Albuminoids	·2605	·0501	·9136
2. Indeterminate nitrogenous matters	·1471	nil.	·0278
3. Theobromine	·0476	·0164	·0880
4. Caffeine	·0119	·0028	nil.
Fat	1·6524	·0199	1·276
Glucose	·0089	·0473	8·708
Sucrose	·0495	·0043	nil.
Starch	·3186	·0617	·3999
Astringent matters ...	·2643	·0051	·1546
Pectin, etc.	·0745	·0532	·8942
Cacao-red	·0833	·0333	·5671
Digestible fibre... ...	·1519	·3105	3·6352
Woody fibre	·1867	·1161	4·7522
Tartaric acid, free ...	·0020	·0286	·2246
Acetic acid, free ...	nil.	trace.	·0530
Tartaric acid, combined	·0263	·0166	·5213
Iron Peroxide	·0007	·0005	·0081
Magnesia	·0245	·0034	·0907
Lime	·0056	·0014	·0332
Potash	·0343	·0117	·3217
Soda	·0036	·0007	·0065
Silica	·0008	·0002	·0072
Sulphuric anhydride ...	·0026	·0015	·0288
Phosphoric anhydride ...	·0564	·0046	·0864
Chlorine	·0016	·0024	·0023
	5·3912	4·7296	89·7898
1. Containing nitrogen ...	·0417	·0096	·1465
2. „ „ ...	·0233	nil.	·0045
3. „ „ ...	·0146	·0050	·0270
4. „ „ ...	·0232	·0008	nil.
Total nitrogen ...	·0830	·0154	·1780

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The fruit of Calabacillo contained less water but distinctly more nitrogen, potash and phosphoric anhydride than that of Forastero. The kernels of the beans of Calabacillo were distinctly richer in the alkaloids, also in astringent matter and in cacao-red than were those of Forastero, the result being that the beans of the former variety were of a harsher, more astringent flavour than those of the latter. The beans of the two varieties showed but little difference in their contents of fat, but those of Forastero were of higher contents of starch and sugars. In the cuticles and pulp from Calabacillo there were found somewhat lesser amounts both of the alkaloids and of starch and sugars than in those from Forastero. In the husks of both varieties small amounts of theobromine less than 1 per cent. were found, but no caffeine, which was present in small quantities in the kernels and cuticles of both varieties, was found in either. But little difference existed in the husks of both varieties in their contents of nitrogen and phosphoric anhydride, but those of Calabacillo contained the higher proportion of potash. When, however, the higher proportion of husk in the fruit of Forastero are taken it appears that this variety returns more nitrogen, more phosphoric anhydride and but little less potash to the soil in the waste husks than does an equal weight of the fruit of Calabacillo. But it requires double the weight of fruit of Forastero than of Calabacillo to produce an equal weight of cured cacao, hence the return to the soil by the husks is more than twice as great in the case of the former than that of the latter.

Assuming that the average yield here of the variety Calabacillo is 250 lbs. and that of Forastero 150 lbs. of cured cacao per acre respectively, we find that the amounts of the constituents of plant food removed from the land annually in the whole fruit, returned to the soil in the husks and either sold in the cured cacao or lost in the sweatings from the fermenting boxes are as follows:—

POUNDS PER ACRE PER ANNUM.

Variety of Cacao.	Calabacillo.			Forastero.		
Parts of fruit referred to.	Whole fruit.	Refuse husk.	Beans and pulp.	Whole fruit.	Refuse husk.	Beans and pulp.
Weight per acre.	6,200	5,000	1,200	6,900	6,200	700
Nitrogen	20·15	8·85	11·30	19·04	11·78	7·26
Phosphoric anhydride	9·42	4·10	5·32	10·14	5·95	4·19
Potash	29·01	22·70	6·31	25·39	22·19	3·20
Lime	2·60	1·95	·65	2·76	2·29	·47
Magnesia	7·44	4·75	2·69	8·21	2·66	1·95

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The unavoidable loss per acre in British Guiana as compared with that in Venezuela given by Marcano, and with that in Guadeloupe reported by Boname is as follows :—

lbs. PER ACRE PER ANNUM.

	Demerara.		Venezuela.	Guadeloupe.*
	Calabacillo.	Forastero.	Varieties not stated.	
Nitrogen	11·30	7·26	7·8	7·3
Phosphoric anhydride ...	5·32	4·19	4·5	2·8
Potash	6·31	3·20	3·7	4·3
Lime	·65	·47	1·4	·4
Magnesia	2 62	1·95	1·	1·4

There is a general concordance in these results showing the low amounts of constituents necessarily removed from the soil of the production of a crop of cacao.

Where the Erythrina is used as a shade tree, manuring should be directed largely towards the upkeep of the potash and phosphates necessary to enable the shade trees to do their part as nitrogen collectors and where no shade trees are used the mineral manuring ought to be more largely supplemented by nitrogen. Thus the following mixtures or mixtures of other materials yielding the same proportions of nitrogen, phosphates and potash per acre might be advisedly tried on cacao plantations :—

	Erythrina used for shade.	*Not shaded.*
Nitrate of Soda	1 cwt. ...	2 cwt.
Superphosphate of lime 36 % soluble	¾ ,, ...	½ ,,
Potash sulphate	1 ,, ...	½ ,,

The materials should be well mixed and applied in quantity according to the number of trees planted per acre around each tree at a distance of about two to three feet from the stem.

An excellent way of applying phosphatic manures to the cacao tree is by the use of slag phosphate. This has given highly satisfactory results, both in British Guiana and in Grenada. Where plantations are being newly started much advantage to the growth of the plants may be obtained by mixing the soil in the immediate vicinity of where the cacao is to be planted with from two to four lbs. of slag phosphate meal.

Attention has also been directed to ascertaining the changes which the beans with the surrounding pulp undergo during the operations of fermenting and curing. For this purpose cured beans were analysed of the two varieties from the same plantation

* Average return per acre assumed to be 450 lbs.

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on which the samples of the fruits had been grown. The cuticles and the husks of the beans were separately examined, the composition of the whole bean being ccalculated from the figures thus obtained. The analyses were conducted on precisely the same lines and by the same methods as those of the various parts of the fresh fruit. Unfortunately, the two varieties are never, as far as our experience goes in the West Indian colonies kept separate during fermentation, and we were forced to select our own samples from out of a very large sample of cured beans of the mixed kinds. Mr. J. H. Hart kindly examined the samples drawn and considered them to consist of typical beans of the two varieties.

The following show the results of these analyses compared with those of the analyses of the similar parts of the fresh fruit dried as before described in the Laboratory :—

TABLE VII.

COMPOSITIONS OF THE DRIED AND THE FERMENTED AND CURED BEANS, CUTICLES AND ADHERENT PULP OF CALABACILLO.

	Dried.	Fermented and Cured.
Water...	5·000	7·169
1. Albuminoids	9·704	7·213
2. Indeterminate nitrogenous matters ..	·681	3·509
3. Theobromine	2·023	1·549
4. Caffeine	·186	·103
Fat	38·181	40·744
Glucose	2·143	·909
Sucrose	·079	·024
Starch	5·980	5·249
Astringent matters	9·900	5·306
Pectin, etc.	1·822	2·671
Cacao-red	4·404	2·420
Digestible fibre, etc.	12·048	11·615
Woody fibre	5·515	5·563
Tartaric acid, free...	·629	0·535
Acetic acid, free	nil.	·869
Tartaric acid, combined	·974	1·114
Iron peroxide	·044	·105
Magnesia	·559	·686
Lime	·134	·207
Potash...	1·312	1·125
Soda	·55	·120
Silica	·022	·065
Sulphuricanhydride	·482	·057
Phosphoric anhydride	1·098	1·113
Chlorine	·044	·020
	100·319	100·000
1. Containing nitrogen	·974	1·080
2. ,, ,, ...	trace.	·640
3. ,, ,, ...	·492	·315
4. ,, ,, ...	·076	·099
Total nitrogen	1·542	2·134

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TABLE VIII.

Cuticles of Cacao Beans, Variety "Calabacillo."

		Dried.	Fermented and cured.
	Water	12·400	12.400
1	Albuminoids	6·092	6·750
2.	Indeterminate nitrogenous matters ...	traces.	4·006
3.	Theobromine	1·599	1·023
4.	Caffeine	·272	·355
	Fat	2·946	·4000
	Glucose	4·811	·476
	Sucrose	·240	·143
	Starch	6·271	4·865
	Astringent matters	2·621	2·113
	Pectin, etc.	5·408	6·140
	Cacao-red	3·391	3·00
	Digestible fibre, etc.	36·388	35·721
	Woody fibre	8·932	9.840
	Tartaric acid, free	2·913	·420
	Acetic acid, free	nil.	·720
	Tartaric acid, combined	2·010	3·450
	Iron peroxide	·026	·057
	Magnesia	·756	·999
	Lime	·358	·266
	Potash	1·260	1·821
	Soda	·272	·219
	Silica	·013	·200
	Sulphuric anhydride	·139	·085
	Phosphoric anhydride	·763	·912
	Chlorine	·119	·019
		100·000	100·000
1.	Contains nitrogen	·974	1·080
2.	„ „	traces.	·640
3.	„ „	·492	·315
4.	„ „	·076	·099
	Total nitrogen	1·542	2·134

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TABLE IX.

KERNELS OF THE BEANS OF "CALABACILLO" DRIED, AND FERMENTED AND CURED.

	Dried.	Fermented and cured.
Water	5·000	6·080
1. Albuminoids	10 202	7·310
2. Indeterminate nitrogenous matters ...	·809	3·406
3. Theobromine	2·059	1·659
4. Caffeine	·164	·058
Fat	44·574	48 400
Glucose	1·510	1·000
Sucrose	traces.	nil.
Starch	5·735	5·329
Astringent matters	7·624	5 972
Pectin, etc.	1·586	1·950
Cacao-red	4·497	2·300
Digestible fibre, etc.	7·287	6 182
Woody fibre	4·617	4·600
Tartaric acid, free	·120	·560
Acetic acid, free	nil.	·900
Tartaric acid, combined	·726	·624
Iron peroxide	·048	·115
Magnesia	·493	·621
Lime	·082	·196
Potash	1·283	·980
Soda	·364	·477
Silica	·024	·037
Sulphuric anhydride...	·120	·051
Phosphoric anhydride	1·141	1·179
Chlorine	·028	·021
	100·000	100·000
1. Containing nitrogen	1·662	1·170
2. „ „	·129	·545
3. „ „	·634	·511
4. „ „	·047	·014
Total nitrogen	2·472	2·240

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TABLE X.

COMPOSITION OF THE DRIED, AND FERMENTED, AND CURED BEANS, CUTICLES AND PULP OF "FORASTERO."

	Dried.	Fermented and cured.
Water	5·000	7·027
1. Albuminoids	7·203	6·259
2. Indeterminate nitrogenous matters ...	3 3·5	2 641
3. Theobromine	1·461	1 402
4. Caffeine	·331	·431
Fat	37·575	46·263
Glucose	1·263	·586
Sucrose	1·2(9	nil.
Starch	8 545	6 337
Astringent matters	6·053	3·588
Pectin, etc.	2·369	1·457
Cacao-red	2 620	2·883
Digestible fibre	10 420	9·07·
Woody fibre	6·803	6 662
Tartaric acid, free	·687	·420
Acetic acid, free	trace.	·674
Tartaric acid, combined	·964	·981
Iron peroxide	·049	·078
Magnesia	·627	·676
Lime	·157	·163
Potash	1·(33	·945
Soda	·096	·195
Silica	·022	·051
Sulphuric anhydride	0·92	016
Phosphoric anhydride	1·370	1 155
Chlorine	·089	·040
	99 843	100 000
1. Containing nitrogen	1·152	1 001
2. „ „	·523	·423
3. „ „	·440	·4·2
4. „ „	·094	·122
Total nitrogen	2·209	1 968

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TABLE XI.

Cuticles of Cacao Beans, Variety Forastero.

	Dried.	Fermented and cured.
Water	11·840	11·840
1. Albuminoids	6·603	6·130
2. Indeterminate nitrogenous matters ...	traces.	3·394
3 Theobromine	1·808	·909
4. Caffeine	·306	·547
Fat	2 186	8·580
Glucose	5·200	·714
Sucrose	·473	nil.
Starch	6·779	3 682
Astringent matters	·561	4·350
Pectin, etc	5·849	5·895
Cacao-red	3·662	3·100
Digestible fibre	34·100	31 292
Woody fibre	12·753	9 610
Tartaric acid, free	3·148	·420
Acetic acid, free	traces.	1·140
Tartaric acid, combined	1·823	3·456
Iron peroxide...	·052	·218
Magnesia	·379	1 035
Lime	·156	·224
Potash	1·288	2·38
Soda	·078	·194
Silica	·015	·250
Sulphuric anhydride...	·161	·122
Phosphoric anhydride	·509	·807
Chlorine	·265	·023
	99 994	100·020
1. Containing nitrogen	1·056	·981
2. „ „	trace.	·543
3. „ „	·544	·274
4. „ „	·087	·155
Total nitrogen	1·687	1·953

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TABLE XII.

COMPOSITION OF THE KERNELS OF THE BEANS OF FORASTERO, DRIED, AND FERMENTED AND CURED.

	Dried.	Fermented and cured.
Water	5·000	6·280
1. Albuminoids	7·228	6·130
2. Indeterminate nitrogenous matters...	4·081	2 525
3. Theobromine	1 321	1·480
4. Caffeine	·332	·414
Fat	45·831	52·120
Glucose	·247	·566
Sucrose	1·373	nil.
Starch	9·043	6·750
Astringent matters	7 329	3·470
Pectin, etc.	2·068	·770
Cacao-red	2·311	2 850
Digestible fibre	3·969	5·762
Woody fibre	5·435	6·200
Tartaric acid, free	·057	0·420
Acetic acid, free	nil.	·600
Tartaric acid, combined	·729	·596
Iron peroxide	·048	·057
Magnesia	·680	·621
Lime	·153	·154
Potash	·951	·776
Soda	·101	·196
Silica	·024	·020
Sulphuric anhydride...	·072	trace.
Phosphoric „	1·565	1·210
Chlorine	·047	·43
	99·995	100 000
1. Containing nitrogen	1·156	·980
2. „ „	·653	·404
3. „ „	·406	·457
4. „ „	·095	·119
Total nitrogen	2 310	1·960

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When the compositions of these substances are given in percentages it is difficult to perceive the changes in composition which may have taken place during the fermentation and curing. The results obtained have therefore been recalculated on the assumption that the fat in the original beans as submitted to fermentation would undergo little or no change during the process; comparison of the compositions of the portions of the fresh fruit submitted to fermentation and of the corresponding amount of the product yielded is thus approximately obtained In the germination of the seeds the fat is used up as food for the plantlet, but in the process of fermentation and sweating germination is so quickly checked that the more readily available sugars are not all absorbed or used up. Thence it is not likely that the fat will undergo appreciable change. These are given for both varieties in the following:—

TABLE XIII.

CHANGES TAKING PLACE IN THE KERNEL OF THE BEANS OF "CALABACILLO" DURING FERMENTATION AND CURING.

	Fresh Beans.	Cured Beans.	Loss in Curing.
Water	37·637	3·675	33·962
Albuminoids	6 696	4·419	2·277
Indeterminate nitrogenous matters	·531	2·059	1·521
Theobromine	1 352	1·003	·349
Caffeine	·108	·032	·076
Fat	29·256	29·256	nil.
Glucose	991	·604	·387
Sucrose	trace.	nil.	..
Starch	3 764	3·221	·5 3
Astringent matters	5·004	3·610	1·394
Pectin, etc.	·657	1·178	+ ·521
Cacao-red	2·952	1·390	1·562
Digestible fibre	5·112	3·737	1·375
Woody fibre	3 030	2·780	2 0
Tartaric acid, free	·079	·328	+ ·259
Acetic acid, free	nil.	·544	+ ·544
Tartaric acid, combined	·477	·377	·100
Iron peroxide	·032	·069	+ 037
Magnesia	·324	·375	+ 051
Lime	·054	·118	+ 0·4
Potash	·842	·592	·250
Soda	·239	·2·8	+ ·049
Silica	·016	·0 2	+ ·006
Sulphuric anhydride	·0·9	·031	·043
Phosphoric anhydride	·739	·712	··37
Chlorine	·019	·012	·007
	100 0	60 442	

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TABLE XIV.

RESULTS OF FERMENTING AND CURING 100 PARTS OF THE BEANS WITH CUTICLES AND PULP OF "CALABACILLO."

	Fresh.	Cured.	Loss in Curing.
Water	61·780	2·702	59·078
Albuminoids	3·904	2·719	1·185
Indeterminate nitrogeneous matters ...	·274	1·168	+ ·894
Theobromine	·814	·584	·230
Caffeine	·075	·039	·036
Fat	15.361	15·361	nil.
Glucose	·862	·342	·520
Sucrose	·032	·009	·023
Starch	2·406	1·979	·427
Astringent matters ...	2·776	2·000	·776
Pectin, etc....	·733	1·007	+ ·374
Cacao-red	1·772	·912	·860
Digestible fibre	4·847	4·379	·468
Woody fibre	2·219	2·074	·145
Tartaric acid, free	·253	·201	·042
Acetic acid, free	nil.	·327	+ ·327
Tartaric acid, comb. ...	·392	·420	+ ·028
Iron peroxide	·018	·039	+ ·021
Magnesia	·225	·258	+ ·033
Lime	·054	·078	+ ·024
Potash	·528	·424	·104
Soda	·143	·045	·098
Silica	·009	·024	+ ·015
Sulphuric anhydride ...	·194	·021	·173
Phosphoric anhydride ...	·442	·419	·023
Chlorine	·012	·007	·011
	1001 32	37·538	

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TABLE XV.

RESULTS OF THE FERMENTATION AND CURING OF 100 PARTS OF THE BEANS, CUTICLES AND PULP OF "FORASTERO."

	Fresh.	Cured.	Loss in Curing.
Water	58·261	2·570	55·754
Albuminoids	3·165	3·233	·932
Indeterminate nitrogenous matters	1·452	·940	·510
Theobromine	·641	·500	·141
Caffeine	·145	·154	+ ·009
Fat	16·509	16·509	nil.
Glucose	·555	·209	·246
Sucrose	·531	nil.	·531
Starch	3·754	2·261	1·493
Astringent matters ...	2·659	1·280	1·379
Pectin, etc....	1·261	·520	·741
Cacao-red	1·151	1·028	·123
Digestible fibre, etc. ...	4·578	3·236	1·342
Woody fibre	2·989	2·377	·612
Tartaric acid, free	·302	·150	·152
Acetic acid, free	trace.	·240	·240
Tartaric acid, comb. ...	·423	·350	·073
Iron peroxide	·021	·028	+ ·007
Magnesia	·275	·241	·034
Lime	·069	·058	·011
Potash	·454	·337	·117
Soda	·042	·069	+ ·027
Silica	·009	·018	+ ·009
Sulphuric anhydride ...	·040	·006	·034
Phosphoric anhydride ...	·602	·412	·190
Clorine	·039	·014	·025
	99·927	35·679	

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TABLE XVI.

CHANGES TAKING PLACE IN THE KERNELS OF THE BEANS OF "FORASTERO," DURING FERMENTATION AND CURING.

	Fresh Beans.	Cured Beans.	Loss in curing.
Water	36·567	3·687	32·880
Albuminoids	4·829	3·599	1·227
Indeterminate nitrogenous matters	2·725	1·482	1·243
Theobromine	·882	·869	·013
Caffeine	·222	·243	+ ·021
Fat	30·602	30·602	
Glucose	·165	·332	+ ·167
Sucrose	·917	nil.	·917
Starch	6·038	3·963	2·075
Astringent matters ...	4·894	2.037	2·857
Pectin, etc.	1·380	·452	·928
Cacao-red	1·543	1·673	+ ·140
Digestible fibre	2·821	3·377	+ ·556
Woody fibre	3·458	3·640	+ ·192
Tartaric acid, free	·038	·246	+ ·218
Acetic acid, free	nil.	·352	+ ·352
Tartaric acid, combined ...	·487	·350	·137
Iron peroxide	·032	·033	+ ·001
Magnesia	·454	·364	·090
Lime	·105	·090	·015
Potash	·635	·455	·080
Soda	·068	·115	·057
Silica	·016	·012	·004
Sulphuric anhydride ...	·48	trace.	·048
Phosphoric anhydride ...	1·045	·710	·335
Chlorine	·032	·025	·007
	100·000	58·708	

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In the case of the variety Calabacillo we find that 100 parts of the fresh material submitted to fermentation and curing lose 6·25 per cent. of their weight of which 59 is water and 3·5 organic and mineral matters. In the kernels of the beans the loss on 100 parts amounts to 39 4, of which 6·5 parts consist of solid constituents.

In the variety Forastero, 100 parts of the material submitted to fermentation and curing, yield 35·6 parts of cured cacao a loss of 64·4 per cent. ensuing, of which 55·7 is water and 8·7 solid constituents. The kernels of the beans lose 41·3 per cent. during fermentation and curing, of which 8·4 parts are solid constituents.

It is evident that when submitted to a similar fermentation and curing, beans of the variety Forastero lose a higher proportion of their weight than do the small flat beans of Calabacillo.

In both cases a considerable loss of the albuminoid constituents ensued, with, in the case of Calabacillo, an increase in the indeterminate nitrogenous matters. In Forastero, a loss of the latter also appeared to have taken place. In both cases we find a loss of the alkaloidal constituents has taken place, this being greater in Calabacillo than in Forastero. A marked loss of the sugars has occurred and also of the starch, pectin, gums and digestible fibre, this being much greater in the case of Forastero than in that of Calabacillo. The astringent matters and cacao-red have also decreased in about equal proportions on the two varieties. Little change has taken place in the total quantities of tartaric acid present, but the fermented and cured beans contain a small proportion of acetic acid not present in the original material. Both varieties have lost some of the more soluble constituents of their mineral ingredients.

Comparison of the losses apparently undergone by the whole material submitted to fermentation, and by the kernels of the beans lead to the conclusion that, as might be expected, a certain amount of change in place has occurred in the constituents of the kernels of the beans and the cuticles and pulp. The kernels show a much more marked loss of astringent matters than do the whole beans and to this loss much of the improvement in flavour must probably be due.

It is also seen by examination of these results that it is probable that during the sweating process slight changes in the position of the constituents of the beans of the two varieties have taken place, leading in some cases to apparent gains of constituents in one or other of the kinds. It was found that the original sample consisted approximately of one-fifth beans of Calabacillo and four-fifth beans of Forastero.

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The following shows the losses resulting from the fermentation of the mixture and we think may be considered as a fairly reliable indication of the changes which ordinarily take place during the fermentation and curing of cacao :—

TABLE XVII.

LOSSES RESULTING FROM THE FERMENTATION AND CURING OF A MIXTURE OF BEANS OF "CALABACILLO" AND "FORASTERO."

Water		56·419
Albuminoids		·982
Indeterminate nitrogenous matters		·229
Theobromine		·159
Caffeine		nil.
Fat		nil.
Glucose		·301
Sucrose		·429
Starch		1·280
Astringent matters		1·258
Pectin		·518
Cacao-red		·270
Digestible fibre		1·167
Woody fibre		·518
Tartaric acid, free		·130
Acetic acid, free	+	·257
Tartaric acid, combined		·053
Iron peroxide	+	·010
Magnesia		·021
Lime		·004
Potash		·114
Soda		·002
Silica	+	·010
Sulphuric anhydride		·030
Phosphoric anhydride		·156
Chlorine		·022

There has occurred a loss in almost all constituents of the cacao, the only gains being in acetic acid, a product of the fermentation, and in iron peroxide and silica due to dirt and dust picked up during the final drying. As a check on the accuracy of these results, a sample of the liquid running from the sweating boxes was obtained, the constituents of which consist of matters removed from the fermenting material and was found to contain with the exception of theobromine, either the missing soluble constituents or the soluble products of their alteration and of that of the less soluble carbohydrates.

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TABLE XVIII.

COMPOSITION OF THE SWEATINGS FROM A MIXTURE OF CALABACILLO AND FORASTERO.

	Water	84·817
1.	Albuminoids	·062
2.	Indeterminate nitrogenous matters ...	·250
	Glucose	11·604
	Sucrose	·638
	Astringent matter, &c.	·354
	Alcohol	·180
	Tartaric acid, free	·340
	Acetic acid, free	·892
	Acetic acid, combined	·290
	Iron peroxide	·038
	Magnesia	·074
	Lime	·029
	Potash	·354
	Soda	·004
	Sulphuric anhydride	·021
	Phosphoric anhydride	·038
	Chlorine	·007
		100·000
1.	Containing nitrogen	·010
2.	„ „	·040

Examinations made by us of the process of sweating showed clearly that at first an alcoholic fermentation takes place accompanied by a rise in temperature of the material; later a little acetic ether is produced either as a direct product of fermentation or by the interaction of the alcohol and the acetic acid produced, and that, finally, the fermentation becomes an acetic one, the temperature in the fermenting boxes gradually rising so high as to practically stop the alcoholic fermentation.

The results of the examinations and analyses show that the process of fermentation or sweating in cacao consists in an alcoholic fermentation of the sugars in the pulp of the fruit accompanied by a loss of some of the albuminoid and indeterminate nitrogenous constituents of the beans. Probably the albuminoid constituents are first changed into amides and other

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simpler combinations which may be further broken up during the process of fermentation. Some parts of the carbohydrates other than sugars undergo hydrolysis and either escape in the runnings from the boxes in the form of glucose, or undergo in turn the alcoholic and acetic fermentations.

During this change some of the astringent matters to which the somewhat acrid taste of the raw beans is due are also hydrolysed, and thus a marked improvement in flavour is gained. Small quantities of the mineral constituents, principally of potash and phosphoric acid, are removed from the beans in the liquid escaping from the fermenting material. A slight loss in woody fibre is shown, which may be due to loss of portions of the cuticle during the operation of drying, or to changes in it by hydrolysis during fermentation.

This work has necessarily only resulted in a partial and incomplete study of the results of the fermentation. The study of the changes which take place in various kinds of beans and during variously modified conditions of fermentation must be left to botanists and chemists in colonies and countries where Cacao is an important product. Work already done in this line is fully compensated if it leads others more favourably situated to take up the study of this interesting and intricate subject, and, at any rate, the record of the investigation may be of some service and guidance to the owners and managers of plantations and to those contemplating purchasing suitable land for establishing plantations.

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CHAPTER XIII.

Food Value of Cacao, Manufacture, &c.

LONG series of analyses were published some years ago by P. L. Simmonds in "Tropical Agriculture," but that author remarks, that the results are "not very flattering to chemical science, the analyses being of the most contradictory character, and containing discrepancies which cannot be at all reconciled with each other"—but he nevertheless reduces them as far as he is able to an average, as seen in the following table:—

Cacao butter	...	...	...	50
Albuminoids	...	...	...	20
Starch	...	...	...	13
Salts	...	...	...	4
Theobromine	...	...	...	2
Miscellaneous	...	...	...	11
				100

Professor Church's analysis of cured Cacao is quoted in the Chapter on Fermentation. Theobromine, according to the Professor, "is the active principle of Cacao; and the taste and aroma are mainly due to an essential oil and to Tannin," and he deems it a milder and less stimulating beveraget han tea or coffee. I doubt much, however, if Cacao of the class he refers to, was that which obtained for it the name of "Theobroma," or "Food for the Gods."

The manufacture of Cacao as now carried out in Europe and America presents a great contrast to the primitive methods of preparation, which methods are found still to exist in the countries producing it.

The Professor gives four forms of preparation in which Starch, Flour, Sugar, Vanilla, Bitter Almonds, Cinnamon and other substances are used as adulterants, some to form "*Soluble Cacao*," some

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"Chocolate," some "Flake or Rock *Cacao*" and some "Pressed *Cacao*"—and in most of these a portion of the original fat of the bean has been removed.

He says:—*that most of the Cacao consumed in Europe is prepared for use by admixture with other substances or by removing part of the fat or 'Cacao butter.' Cacao-nibs, if simply ground, would yield a rich but heavy food but not a beverage. It may indeed be shown that 100 parts of Cacao-nibs contain heat-givers equivalent to 132 parts of starch, while the flesh-formers present amount to no less than 17 parts, the ratio of the latter being as 1 to 8. One pound of Cacao-nibs might in fact produce as much as 2¾ oz. of the dry nitrogenous substance of muscle.*

This shows that one pound of Cacao-nibs is more than equal in flesh-forming constituents to one pound of lean mutton chop, which is estimated to contain but 2 oz. of the dry nitrogenous substance of muscle or flesh But we can't eat a pound of Cacao-nibs at any one time, and it is seldom that more than ½ oz. is used for a breakfast cupful, and even to this is added a certain proportion of milk and sugar. The value of the milk as a food constituent being as ¾ oz of the dry nitrogenous substance of muscle and flesh to the lb. So that Professor Church's remark that Cacao-nibs would yield a heavy food, but not a beverage, is somewhat wide of the mark, for it actually yields only a beverage, and is seldom, except on emergencies, taken as food.

If it was consumed as "nibs" it would certainly be a "heavy food" as it appears to contain 50 % of Fat, and 17 % of Albuminoids besides other constituents. No one eats it in the form of "nibs" however, but small quantities in solution, and therefore when we take of prepared Cacao a part equal to $\frac{1}{32}$ part of a pound, adding 4 ozs. boiling water and 4 ozs. milk; we have according to the Professor's own analysis, the sum of 1⅜ drams + 3 drams or a total of 4⅜ drams of flesh-forming constituents in a cup of Cacao made from the ground nibs unadulterated, of which 3 drams are supplied by the added milk, or a total value of ($\frac{1}{10}$) one-tenth of a pound of mutton chop. What proportion of nutriment is contained in a cup of Cacao made from the various preparations, we are not able to gather, but we should estimate it at a very much lower figure.

That Cacao-nibs, simply roasted and ground, will yield a beverage of excellent quality when properly prepared there can be no doubt, though perhaps not one calculated to suit all tastes but once the palate is "educated" to the flavour, it is preferred to any of the adulterated forms or preparations. In samples of Cacao, or "Cocoa" made by the best makers no less than 60 % of

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Sugar has been found. This large amount of sugar is accounted for by the fact that without this addition it does not sell. Not a little prejudice exists as to the digestibility and indigestibility of Cacao Fat, and this prejudice is taken advantage of by the manufacturers in making their preparations. It is somewhat curious to note however, that some of the fat extracted from the preparation intended for use as a beverage is used in the preparation of confectionery, such as "Chocolate Creams," when no question whatever arises as to its indigestibility. Many indeed who object to a certain amount of fat with their breakfast cacao, use ten times the amount of quite as indigestible a fat, in the form of butter, without a thought of indigestion. The value of Chocolate Creams, Chocolate Stick and other "*Bon Bons*" as a food may be estimated from the analyses. They contain from 12 to 40 % of Cacao which has a large percentage of Fat, some starches, and some albuminoids, and these added to the Food value of 60 % of sugar will give total value which will be found overestimated in the majority of cases both by sellers and consumers. If the public could be persuaded to demand pure Cacao, adding the sugar themselves they would be better served.

Manufacture of Chocolate.

The methods generally employed in Trinidad in manufacturing Chocolate from the Cacao bean are extremely simple, and the same in principle as those practised throughout Cacao growing countries; but there are a few persons who produce an article little inferior in point of manufacture to that produced in Europe.

The bean after being cured and dried in a manner fit for sale can be used at any time for manufacturing into chocolate. The first process is to roast the beans in a cylinder over a slow fire, until they assume a fine brown colour, but not to heat them to such a degree as to burn them, or to destroy the essential oil which they contain, for Cacao-beans once burnt or scorched can never make up a cup of first-class chocolate. When browned sufficiently the testa easily separates from the inner portion of the seed and can be cracked off and fanned away as soon as the beans are cool enough to handle. Care should be taken to grind quickly after roasting, as once roasted, Cacao soon loses flavour and aroma, and the manufactured article should always be kept in sealed or close fitting receptacles.

The "nibs" are put upon a clean piece of free stone about 2 feet square, perfectly smooth, another piece of the same material, somewhat rounded, being used as a grinder. Rubbed for some little time and frequently turned with a small *spathula*, the beans are reduced to a paste, the fat they contain assisting the operation, but the grinding must be continued until the

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paste becomes perfectly smooth and even. If sweet chocolate is desired to be made, sugar should be added; if "unsweetened" nothing more has to be done but to make the paste up into such sizes of blocks or rolls as may suit the fancy of the manufacturer or the convenience of housewife. These balls, rolls, or blocks are then allowed to set or harden, which they will do in a few hours' time, after which they can be transported any distance. The operations of roasting and grinding should always be done in dry weather.

No adulteration is required, but still to suit some palates, Vanilla, Nutmeg, Cloves, Cinnamon, and various spices may be added, but these combinations are in our estimation not equal to the flavour of the *virgin* Cacao, provided the volatile essential oil has not been destroyed during the process of roasting, during which process it appears to be developed.

A cup of most delicious chocolate can be made from the rolled or caked Cacao in about three minutes, in the following manner:—Grate about half an ounce of ball chocolate into an enamelled saucepan, adding sufficient boiling water to cover it; let it simmer for two or three minutes, add sugar and hot milk to taste and serve. If preferred equal parts of milk and water may be used. The substance removed from the bean as *fat* by the more elaborate methods in which Cacao is prepared is known as "Cacao-butter." This is a valuable concrete fat melting at 100° Fahrenheit which is expressed from the paste of the Cacao-bean by pressure while subject to steam or sun heat. On cooling it becomes an opaque dry chocolate colored substance, somewhat brittle and shows a waxy fracture. The coloring is easily removed by filtering while hot, through animal charcoal, when the fat becomes a clean white. It has a pleasant chocolate odour and a bland flavour, and is much used for pharmaceutical preparations. It is chiefly remarkable for having but little tendency to rancidity.

From the fact that clean fats have a remarkable affinity for the volatile or essential oils, it appears probable that a proportion of the aroma of chocolate is lost by the removal of the Cacao-butter, and this fact would alone account for the superiority of the flavour of that Cacao in which the natural fat is all present, over that from which it has been removed. Which way the manufacturer must make it, the public decides of course. Usually the less the manufacturer adulterates a pure article, the better are his prospects for the future of his business, but in Cacao the converse appears to be the case. It is clear that more Cacao would be sold if the mixture of foreign substances was disallowed, and the planter would in consequence reap a decided benefit from the greater demand.

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If the operator desires to make a Cacao powder, he has to express a large proportion of the fat which can readily be done in any common press. The Cacao paste must be handled in a high temperature so that all the fat is in a melted state, and the apparatus must also be kept well warm. This can, in Trinidad, be effected by working in the Sun, but in a temperate climate, artificial heat is required, and is employed in all the Factories. The paste is put between thin layers of cloth, neatly folded so as to prevent escape and then placed layer upon layer in a strong press box, worked either by simple screw or by hydraulic pressure. Sufficient of the fat can in this way be extracted to render the layers of paste dry, and formed into solid thin cakes. If these are now taken and rubbed through a fine sieve, a cacao powder will be produced, in flavour equal, if not superior, to the finest brands upon the market, and unadulterated and pure. Sugar can always be added by the consumer, and no starch is necessary to make the article into palatable form.

Cacao powder pure and unadulterated may well be called "Food for the Gods" from the delicious flavour and aroma it exhibits, but the lower qualities of the manufactured article commonly sold and largely advertised would in many instances be well named in the words "Food for the Pigs," as they certainly contain but a very small percentage of pure Cacao.

To ascertain whether there was any essential difference in the character of various samples of the Cacao Bean when worked up or manufactured for consumption three samples were obtained from one of our largest dealers.

These samples were accurately weighed to 10 lbs. each, and were then roasted and ground and the fat extracted by an ordinary press.

The percentage of fat is not so large as might have been taken, but as in each case the means used was identical, the results are directly comparable.

The character of each Cacao was exhibited most distinctly the colour and flavour of the dry powder, and by the colour, character and flavour of the fat extracted.

The Cacao powder, Cocoatina, or Cocoa essence produced, is an article which can be used in the same manner as the ordinary Cacao powder of the manufacturers, and is a perfectly pure article. The value of the powder can be estimated if we allow a certain per cent. for loss in the process of manufacture. Our own experience is too limited to fix this with accuracy, but it may be for our present purpose taken as 20 per cent.

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The Cacao powder produced, is seen to average some 55 per cent. of the total weight of Cacao operated upon, and therefore we have a saleable article at a loss of 45 per cent. of the original weight. Now the value of the cacao at the time of the operation was averaged at 14 cents per lb., and therefore the cost of the powder not allowing for value of fat, and sale of waste—and not admitting cost of manufacture, is more than double the cost of raw material—or some 30 cents per lb. When, however, some 15 per cent. or 20 per cent. fat is sold at 1/3*d.* per lb. and the husk at a lower value, it will greatly reduce the cost of manufacture, and it can be clearly seen that *Pure Cacao Powder* can be produced at reasonable rates, leaving a good margin of profit, and also that the admixture of starch and sugar is not in any way required, either for the purpose of making it palatable or as an improvement to the keeping qualities of the article. The public should therefore put down adulteration by demanding nothing but a pure Cacao powder, which is in every way a palatable and nourishing beverage.

One of the facts to be noted is, that the mild flavoured and light colored Venezuelan Cacao is rated at the same value as ordinary Trinidad, although it is evident it produces a Cacao powder in every respect superior to "Ordinary" Trinidad Cacao.

The following are the tables of results of our late experiments :—

No. 1.—Venezuelan Fine Clayed Cacao, valued at 14c. per lb.

1.	Weight received from G. G. & Co....	10 lbs.
2.	Weight when roasted and cleaned	7·55 ,,
3.	Weight of Husk	1·68 ,,
4.	Weight of dry Cacao after fat was removed ...	5·50 ,,
5.	Weight of Fat extracted from 7·55 lbs. ...	1·23 ,,
6.	Loss during roasting and cleaning ·77 lbs.	
7.	Loss during grinding and expression of fat ·82 lbs.	
8.	Total loss in manufacture	1.59 ,,
	Loss roasting, cleaning and extracting fat and husk	32·7%
	Dry Powder	55·0%
*	Fat	12·3%
		100·0

Notes.—The loss is greater than it would be with larger quantities.

Comparing samples Nos. 2 and 3, it is seen that Clay is to be estimated at about 1½%.

* Fat should be slightly more, owing to the absorption by the bags during extraction of first example, possibly 13%.

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No. 2.—Trinidad "Fine Estates" valued 14½c. per lb.

1.	Weight received from G. G. & Co.			10 lbs.
2.	Weight when roasted and cleaned			7·86 ,,
3.	Weight of husk			1·63 ,,
4.	Weight of Cacao after removal of Fat			5·60 ,,
5.	Weight of Fat from 7·86 lbs.			1·64 ,,
6.	Loss roasting and cleaning ...	·51 lbs.		
7.	Loss during grinding and expression of fat	·62 lbs.		
8.	Total loss			1·13 ,,

10 lbs.	Dry Cacao Powder		56· %	
	Fat		16·4 %	
	Loss	27·6	11·3 %	
	Husk		16·3 %	
			100·0	

No. 3.—Trinidad "Ordinary" Cacao, 14c. per lb.

1.	Weight received from G. G. & Co.			10· lbs.
2.	Weight when roasted and cleaned			7·80 ,,
3.	Weight of husk			1·53 ,,
4.	Weight of Cacao after removal of Fat			5·48 ,,
5.	Weight of Fat from 7·80 lbs.			1·61 ,,
6.	Loss during roasting and cleaning ...	·67 lbs.		
7.	Loss during grinding and expressing fat	·71 lbs.		
8.	Total loss			1·38 ,,

10 lbs.	Dry Cacao Powder		54·8 %	
	Fat		16·1 ,,	
	Loss	29·1	13·8 ,,	
	Husk		15·3 ,,	
			100·0	

The author in 1897, had the privilege, through the kindness of the proprietors, of visiting the large Factories of Messrs. Rowntree of York and Messrs. Cadbury of Birmingham. The cleanliness and care with which the various preparations were made in these works is hardly possible to excel, and the materials used were of the finest quality. Regarding adulteration with sugar, manufacturers admit it, and declare that the Public demand it so, and that the sweetest chocolate *sells the best*. While this state of things exist, it is perhaps hopeless to expect any large quantities of pure Cacao preparations to be manufactured, as the Factories cannot be blamed for supplying the popular demand. Nearly all first-class makers, however, make the pure preparations, which can be obtained if asked for, and these are gaining way slowly with the intelligent, but the mass still buys the cheap, sweet and starchy mixtures which are sold under the names of Cacao and Chocolate.

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Wishing to know what was really the percentage of sugar in manufactured Chocolate of the best makers, I obtained a sample which was sold at the rate of three shillings per lb. in Port-of-Spain, the capital of Trinidad. In this pound I found 65 per cent. of sucrose, which might be either cane or beet sugar. At any rate there was present 65 per cent. of sugar, in the one pound of chocolate. Allowing this to have been of the very best class it could not have cost the manufacturers at wholesale prices more than 3 cents per lb.

The 35 per cent. Cacao and other material may be well estimated as follows :—The loss on roasting and grinding Cacao by hand is 27 to 30 per cent. The value of raw Cacao per lb. is about 14 cents, and by adding 30 per cent. to the original cost and make up for waste, we have a value for clean unground Cacao of some 20 cents per lb. Take manufacture, grinding, &c., to represent a value of 100 per cent. (which would be an extreme estimate) we should have 40 cents—as the price of 1 lb. of prepared Chocolate without admixture of sugar. If again, we take 35 per cent. of 40 cents—we have 14 cents for the cost of the Cacao mixed in a pound of chocolate. This added to the cost of sugar (some 14 cents), gives 18 cents or 9d. as the cost of first class prepared Chocolate which is sold at four times this value or 3 shillings per pound.

It seems a curious thing that the public have not as yet become alive to the fact that they are paying for sugar in the form of Chocolate at a ridiculously high rate. For out of every 100 tons of chocolate sold there are 65 tons of sugar sold at 3 shillings per lb. or at the rate of £336 per ton, while the poor planter is glad if he can get some £8 to £12 per ton.

The "manufacture" of large establishments is not dealt with in this treatise. To discuss (even if we were competent to do so) the various blendings of the different classes of produce, the "milling," the sweetening, the packing, and the thousand and one operations which go on in a large factory would more than fill 100 pages by itself, and I therefore leave it for more able hands.

The word "Cocoa" appears to be of European origin, and has caused no little confusion owing to the similarity of its sound to words which name entirely different products, such as Coconut, Coca, Cocoes, &c., &c. *Cacao* is the original name and under the rules of priority, it is considered the proper one to use, and it has therefore been adopted throughout this work in preference to the English spelling.

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CHAPTER XIV.

Transport of Seed and Living Plants.

UCH trouble is experienced by intending planters in sending Cacao seed to a distance. The author has however had considerable experience in forwarding to Ceylon, West Africa, Nicaragua, Europe and America. It has been found best where quantities are required, to sow the seed in light earth in Wardian cases. In 1893, I personally conveyed 25,000 plants of Trinidad Cacao to Nicaragua, and as successfully brought a smaller number of Nicaragua Cacao to Trinidad. Cases sent to the West Coast of Africa have arrived in splendid condition when sown in Wardian cases, and established plants were safely sent to Ceylon in the same class of package. When seed is to be sent to places requiring a journey of not more than 12 or 14 days, they may be safely sent in the pods. The pods should be carefully picked, and packed without bruising into crates, with clean dry shavings, wrapping each pod first in stout paper. A variety of methods are devised for sending seeds, but the above described is the one I have found most effective. Pods may be packed however in dry sawdust with considerable success. The most essential point needed to ensure successful transit, is to send them only in warm weather or at such times when the temperature will not fall much below 60 Fah. If plants or seeds meet with cold weather even for an hour, such as sometimes occurs on Wharves and Railway Stations, when sending to Europe, it is almost sure to be fatal to both plants and seeds. Small quantities of seed may be sent by post, if care is taken to remove the pulp from them and put them with dry clay, and then pack in moist Coco-nut refuse, in a tin (not wooden) case. When pods are sent they should be collected not more than three days previous to despatch, and kept on a dry floor or shelf previous to packing. In planting seeds we are told by some, that they must be put into the soil in a certain position to do well. Some say the radicle should point upwards, and others that it should stand downwards, and some plant their seed laid flat in the soil. In Nicaragua the seed coat and all the pulp clean down to the

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cotyledons is removed, and the seed put in with the radicle downwards. I have personally tested these positions many times over, without finding any great or distinguishing advantage. When planted without the seed coats however, there is less likelihood of the attack of fungus through the decomposition of the pulp than would otherwise be the case, and the plants come up several days earlier than those sown in the pulp, with testa intact. With regard to the variety of positions, I have planted seeds in all three positions in one box, and after the first fourteen days it was impossible to tell which way they had been planted; as the plants were in the same stage of growth, and indistinguishable one from the other. If, therefore, the golden rule for sowing seeds be followed, which with all seeds is *to place them in their own diameter under the soil*, without regard to position, the planter may surely reckon upon securing healthy and vigorous seedlings. Those who fancy planting them in any one particular way, may do so, therefore, with as much certainty of success as those who use the opposite methods, and yet each will have the separate satisfaction of believing in his method, which in some cases gratifies more than to follow the practices pointed out by experience and the planter Science.

There is probably much yet to be learnt, by the grower, the curer and the manufacturer of Cacao, and the present edition, of this work does not pretend to be perfect any more than its predecessor, or to say everything that might be said on the subject of Cacao. It has, however, been carefully revised in accordance with the present knowledge of the subject, and it is hoped the contents may be found both interesting and useful to Tropical Planters.

May, 1900,

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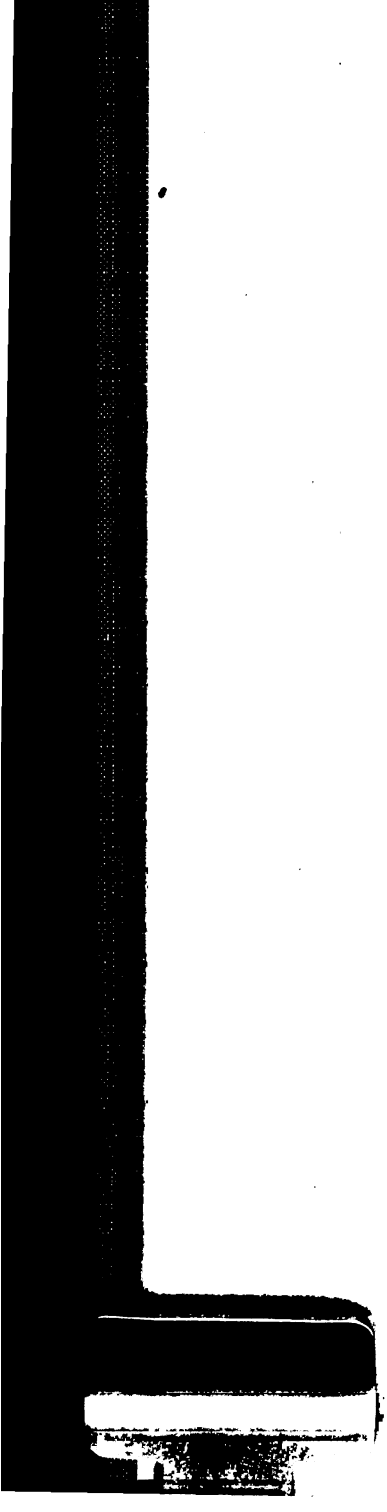

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